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OE FORM 6000, 2/69

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
OFFICE OF EDUCATION

ERIC REPORT RESUME

ERIC ACC. NO.	P.A.	PUBL. DATE	ISSUE
ED 041 187			
CH ACC. NO.			
AA 000 595		70	RIEDEC70

IS DOCUMENT COPYRIGHTED? YES ☐ NO ☒
ERIC REPRODUCTION RELEASE? YES ☐ NO ☒
LEVEL OF AVAILABILITY I ☒ II ☐ III ☐

AUTHOR

TITLE
Report of the Task Group on the Economics of Primary Publication.

SOURCE CODE	INSTITUTION (SOURCE)
BBB03981	National Academy of Sciences, Washington, D.C. Committee on Scientific and Technical Communication

SP. AG. CODE	SPONSORING AGENCY
FGK57295	

EDRS PRICE	CONTRACT NO.	GRANT NO.
1.00;12.70		

REPORT NO.	BUREAU NO.

AVAILABILITY

JOURNAL CITATION

DESCRIPTIVE NOTE
252p.

DESCRIPTORS
*Economics; *Publications; *Periodicals; *Publishing Industry; Federal Aid; *Sciences; Research Reviews (Publications); Professional Associations

IDENTIFIERS Page Charges; SATCOM

ABSTRACT Besides making several recommendations pertaining to the operation and financing of primary journals, this report commented on the limitations of our present understanding of the ecomonics of journal publication and strongly recommended extensive studies to fill this gap. The introduction to the report proper includes sections on genesis, goals, previous studies and procedure used, and the nature of this report. The general perspective section covers: role of primary journals; diversity of journals, sizes, circulations, prices; value of journals to society; production costs; library costs; sources of revenue; foci of opposition to the page-charge system and considerations advanced in favor of page charges. Areas in which recommendations are made include: need for Federal support, governmental policies concerning page charges, monitoring, recommendations to publishers on organization and financial policies, additional recommendations for societies and publishers and further thoughts. The appendix contains: an introduction, guiding principles, present situation and arguments and conclusions. Attachment A lists the organizations and individuals that have contributed information for this study. Attachment B presents the journal population and sampling procedure. Attachment C contains mathematical studies of models. (NH)

GPO 870-390

ED 041 187

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REPORT OF THE TASK GROUP ON THE ECONOMICS OF PRIMARY PUBLICATION

COMMITTEE ON SCIENTIFIC
AND TECHNICAL COMMUNICATION

NATIONAL ACADEMY OF SCIENCES
NATIONAL ACADEMY OF ENGINEERING

Published by the
NATIONAL ACADEMY OF SCIENCES
WASHINGTON, D.C. 1970

AA 000 595

The work of the Committee was funded by the
NATIONAL SCIENCE FOUNDATION
(NSF C-310, Task Order 111)

Standard Book Number 309-01852-8

Library of Congress Catalog Card Number 75-606919

CONTENTS

INTRODUCTION 1

Genesis
Goals
Previous Studies
Procedure Used and Nature of This Report

GENERAL PERSPECTIVE 6

Role of Primary Journals
Diversity of Journals: Sizes, Circulations, Prices
Value of Journals to Society
Production Costs
Library Costs
Sources of Revenue
Foci of Opposition to the Page-Charge System
Considerations Advanced in Favor of Page Charges

RECOMMENDATIONS 15

Need for Federal Support
Governmental Policies Concerning Page Charges
Monitoring
Recommendations to Publishers on Organization and Financial Policies
Additional Recommendations for Societies and Publishers
Further Thoughts

APPENDIX 25

NOTES 241

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INTRODUCTION

GENESIS

The rapidly growing volume of publication in science and technology has brought about changes in the character and readership of many of the journals in which new knowledge is published. Concomitantly, these journals have had to make a succession of economic readjustments. These facts have stimulated much comment and discussion[1]; they were the subject of some concern in the report[2] recently issued by SATCOM (the Committee on Scientific and Technical Communication of the National Academy of Sciences and the National Academy of Engineering). Besides making several recommendations pertaining to the operation and financing of primary journals, this report commented on the limitations of our present understanding of the economics of journal publication and strongly recommended extensive studies to fill this gap. However, just recently—since completion of the SATCOM Report—the tightening of research and development budgets has greatly intensified the concern felt by some groups regarding the costs of publication and the concern of others regarding the economic health of journals. Moved by these concerns, in May 1969 the National Science Foundation asked SATCOM to set up a Task Group on the Economics of Primary Publication analogous to several previous SATCOM task groups created to assist governmental agencies on specific problems. This Task Group was immediately established and was asked to report on the present situation of primary

journals, to survey recent trends and problems, and to develop a perspective for general national policies, with especial attention to the immediate future.

Of the several aspects of journal economics meriting attention at this time, none has aroused more heated discussion than page charges.[3,4] Page charges refer to a journal's practice of asking the institution supporting research submitted for publication to pay an amount proportional to the number of pages of the material published. Payment is "expected," but nonpayment usually does not impede publication of the material submitted. According to the policy enunciated in 1961 by the Federal Council for Science and Technology,[5] such charges, when they meet certain very broad conditions, are considered by the federal government to be a legitimate part of the costs of doing research or development work and, as such, are chargeable to research or development contracts. However, contracting institutions are not at present under any compulsion to honor page-charge assessments for government-sponsored work.

Late in 1968, shortages of research and development funds led many institutions that previously had honored page charges to decline them; as a result some journals became alarmed at this threat to their revenues.[6] Moreover, the "squeeze" felt by some authors led them, alone or through organizations, to attack the basic philosophy of page charges.[3] Therefore, the Task Group was requested to include in its overall survey of journal economics a study of both sides of this issue.

GOALS

We interpreted our assignment as including both the gathering of data and the development of these data into arguments for or against certain policies. We had been asked to report, if possible, within a few months, and a preliminary look at our task convinced us that it should indeed be possible to uncover many useful guides to desirable policies by a brief but intensive study of the characteristics of a well-chosen sample of journals and of the present or immediately foreseeable trends in their circumstances. We tried not only to assess the immediate expediency of various possible measures that might be taken by professional societies, government agencies, and others, but also to seek broad economic and philosophical principles applicable to journal literature as a means of communication among scientists and technologists. We did not, however, undertake to make really long-range predictions or recommendations in which the characteristics of as yet untested technologies of communication would be involved.

PREVIOUS STUDIES

As we have indicated, the importance of the problems of journal economics has long been recognized, and many of these problems have been objects of recent studies, some of them fairly extensive. The planning and execution of the present report were very greatly facilitated by a number of these studies. We shall mention here only some of the more recent of these; the interested reader can trace earlier references through them.

Probably the most comprehensive of the general studies of the economics of journals was made in 1964 by Campbell and Edmisten, of Herner and Company, for the National Science Foundation.[7] These workers surveyed a few hundred U.S. journals judged to be media for primary publication of new research and obtained usable replies to an extensive questionnaire from all of them. They described various characteristics of the journals (bulk, circulation, price, sources of income, etc.) in numerous tables and graphs, usually arranged by field (mathematics, biology, etc.) and/or type of publisher (society, commercial, etc.). They did not attempt a detailed breakdown of publication costs, but some interesting material on costs is contained in a report prepared about the same time by Paige, Martin, and Rosenberg for the American Mathematical Society[8]; however, this report was limited to U.S. journals in mathematics. Other examples of special interest[9-11] include the studies made for the Abstracting Board of the International Council of Scientific Unions[11] that covered the characteristics of journals of certain fields on a worldwide basis, though with little financial data.

In addition to studies with extensive economic statistics, there are many shorter contributions, some consisting of qualitative comments on problems of journal economics and some containing provocative though sketchy quantitative data. A collection of such papers was issued in 1967 by the Engineers Joint Council[12]; a paper by Herwald[12] in this collection shows empirical data for a number of journals of the Institute of Electrical and Electronics Engineers (IEEE) that illustrate the relation of costs to circulation, issue size, and the like, and the relative importance of different elements in costs and revenues. Of the many general discussions of journal economics outside this collection, we shall mention only two,[13] written from the viewpoint of managers of large publishing operations of professional societies.

A number of studies have been aimed specifically at the page-charge practices of journals and reactions to them. Some of these studies have been made for specific fields by querying publishers of a number of journals in the field surveyed (mathematics,[14]

biology,[15] engineering[16]); others have covered all fields.[17,18] Data on percentages of journals using page charges, sizes of page charges, collection rates, and the like, have been tabulated. By far the most comprehensive of these studies is the one by the Biological Sciences Communication Project of the George Washington University,[17] which circulated detailed questionnaires to authors, administrators at universities and other institutions, and others with like responsibilities. We have made use of their findings.

A most interesting attempt to apply methods of economic theory to data on scientific and other learned journals is currently being made in a PhD thesis by Berg.[19] We would like to acknowledge some illuminating conversations and correspondence with Mr. Berg.

PROCEDURE USED AND NATURE OF THIS REPORT

We felt that before embarking on extensive spadework we should reflect a little on what the scientific and technical community—or society as a whole—is trying to accomplish in publishing journals. Consideration of these very basic goals guided our attention to a number of aspects of the production and distribution of journals, some of which fell outside the scope of most of the previous studies cited. Among other things, we came to feel that to make intelligent judgments one must know something about the psychology and habits of all the scientists and technologists involved with journals, and especially of their readers. Having developed this general orientation, we then set about the task of selecting limited, but we hope meaningful, samples of journals, asking certain significant questions about them, and collecting as many answers as possible. (We describe the samples and the several different ways in which we gathered information about them at the start of Section III of the Appendix to this Report and in Attachment B.) Finally, we undertook to analyze the data in the light of what we judged to be reasonable principles and to formulate a limited number of policy recommendations.

Because of foreign travel and other commitments of most of the members of this Task Group during the period of preparation of this report, there have been only limited opportunities for the group to meet as a whole and to work collectively on the large amount of material collected. We have concentrated, therefore, on what we felt to be the several most significant policy recommendations we can make at present and have found that, despite some differences in viewpoint among us, we can agree nearly unanimously on these recommendations; the occasional dissenting opinions will be given in footnotes. These principal recommendations are contained in the Recommendations that follow.

The data and arguments supporting these recommendations appear in a voluminous Appendix prepared by the one member of our group, Conyers Herring, who was able to find time to work through in detail the large amount of material collected. This Appendix contains additional conclusions, not all of which have been fully discussed or accepted by the entire Task Group. Its theoretical sections suggest, as does the work of Berg,[19] that there is reasonably good hope of our soon being able to achieve a better understanding of the interplay of social and market forces in the journal field. Though hastily prepared and full of gaps, this Appendix provides an illustration of the uses to which a more deliberate and continually updated data-collection and operational-research activity could be put. Such a thorough and continuing study, advocated in fact in the SATCOM Report,[2] could well be a regular activity of the Joint Commission on Scientific and Technical Communication proposed therein.

GENERAL PERSPECTIVE

We shall not try to summarize all the material of the Appendix; we suggest that readers interested in a brief survey simply skim the Appendix, noting the table of contents, the underlined passages, and occasional figures. A few especially important points emerge from the data and reasoning in the Appendix that deserve the attention of all readers before they address themselves to the Recommendations section of the Report; therefore, we will discuss these points briefly before introducing the recommendations.

ROLE OF PRIMARY JOURNALS

The current problems of primary journals that we mentioned in the Introduction have led some to wonder whether such journals are an anachronism and should be replaced by some entirely different mode of storage and communication of information. We reject this view: While various new modes offer exciting possibilities for the improvement of communication, they will have to be used in conjunction with journals. Statistics on the rates of growth of the circulations of journals in the last decade or so (see Appendix, Section IIIB.2) and the growth in numbers of journals (see Appendix, Section IIIB.1) show that on the whole buyers are still very interested in them. It is noteworthy that almost no U.S. primary journals have folded in recent years (see Appendix, Sections IIIB.1,

IVA.3). A leveling off in the funds available for science and technology may well, in the long run, even ease the problems of journals by limiting the amount of material they are required to publish.

Journals have both archival and current-awareness roles. In their archival role they have a combination of virtues that alternative systems will not be able to match for a long time: They supply the full text of descriptions of new knowledge that are complete enough to satisfy most of the needs of users of this knowledge; this material is under orderly bibliographic control; it is quickly available in any well-maintained collection; these characteristics are achieved in a free-market system, where both producers and purchasers of information have ample opportunity to exercise judgments in adapting the information system to their needs or to what they believe is the welfare of society. Alternatives to journals offer a stronger challenge in relation to the current-awareness function, that is, keeping workers in a field aware of advances made by others. But even for this role, studies show that the regular browsing of journals continues to fulfill a very important current-awareness function (see Appendix, Section IIIC.2).

DIVERSITY OF JOURNALS: SIZES, CIRCULATIONS, PRICES

The diversity of the journal population is overwhelming. In bulk, the largest journals publish about 500 times as much per year as the smallest. In some fields (physics, chemistry, some areas of biology) the larger journals (say, above 1.5 megawords/year) publish the bulk of new knowledge, while in other fields (mathematics, psychology, many areas of biology, and engineering) the reverse is the case (see Appendix, Section IIIA.1 and Figures 1 and 2). The average journal has been increasing in bulk by about 7 percent a year. The spread in price is also enormous, the "best buy" in 1968 having provided 90 times as many words per penny as the "worst buy" in our sample. Generally, journals published by societies are much cheaper (even for nonmember subscribers) than those issued by private publishers; journals of nonsociety, nonprofit publishers tend to be intermediate. (See Appendix, Section IIIA.2 and Figure 3.) Circulations also vary widely, though few journals of our sample were outside the range 1,500 to 15,000 (see Appendix, Section IIIA.2 and Figure 5). The number of workers in the general field of a journal is obviously the most important factor in its circulation, but price and general quality are also significant factors, and it is not uncommon for different journals with very similar coverage to differ in circulation by a factor of 3 to 5 or more.

VALUE OF JOURNALS TO SOCIETY

The value of journals is often attested in statements such as "Journals are the life blood of research." We agree; nevertheless, it is worth noting that one can make rough quantitative estimates of certain portions of the value of journals to society, estimates that show that this value exceeds a certain lower bound already many times larger than the total cost of producing the journals. For example, one can write:

Social value of journal	=	Value to current subscribers, i.e., to the users they represent	+	Value to others, including future generations

The first term also consists of two parts: Current users receive information from journals both directly, via their own use of them, and indirectly, via contacts with others who have used journals. Thus,

Value to current subscribers	=	Current direct value	+	Current indirect value

Studies of information flow (see Appendix, Sections IIIC.2 and IVA.6) suggest that the latter two terms are comparable with each other. One line of reasoning to get at the current direct value (see Appendix, Section IVA.1) is based on the roughly plausible assumption that on the average the maximum price that a potential subscriber is willing to pay for a journal represents the value of this journal to him; this price, of course, will vary enormously from one subscriber to another. Combination of this assumption with an estimated price-circulation curve (see Appendix, Section IIIA.2 and Figure 7) gives the sums of the value estimates of all the subscribers who actually get the journal. The result is larger than the total cost of producing the journal by a factor that, though hard to estimate reliably because of uncertainties in the price-circulation curve, can hardly be much less than 5 or so for, say, a good general physics journal. Thus the total social value of such a journal is likely to be over 10 times its production cost.

Another way of getting a quantitative clue to value is to study the time people are willing to invest in reading journals (see Appendix, Section IIIC.1). The dollar value of this time, though varying somewhat from field to field, again is typically several times the production cost of the journals. This fact is important not only as a clue to the net value directly received from the journals, which is not likely to be much smaller, but also as an indication of the possible economic value of improving the efficiency with which users can extract the information of value to them.

PRODUCTION COSTS

It is important to distinguish three contributions to the cost of producing a journal (see Appendix, Section IIIA.3 and Figure 8). The first is the basic prerun cost: editorial work, copy editing, composition, proofreading, engravings, and the like, for the technical material submitted. Often this component includes "hidden costs" that do not appear on the books, for example, editor's time or office space donated by a university or other organization. The second contribution is the basic runoff cost: paper and presswork for the technical papers published, binding, wrapping, and mailing, and also monitoring the files of subscribers, and the like. The third category is what may be termed optional costs, that is, costs of operations that are not necessary to the publication of research results but that are considered desirable adjuncts. Such operations include, for example, preparation and printing of advertising and news material or production of reprints and back-number stocks (sometimes large).

Since prerun costs depend only on the bulk of material published, while runoff costs are also proportional to the number of copies printed, the relative magnitudes of these two contributions vary greatly from journal to journal. For most journals, though, the prerun costs outweigh the runoff costs (for example, see Appendix, Figure 35). Both the prerun cost per unit amount of material and the runoff cost per unit amount per copy vary moderately from journal to journal (see Appendix, Sections IIIA.4 and IIIA.5); these variations are in part unavoidable (e.g., due to differences in the density of mathematics), in part a result of conscious choice (e.g., a striving for speedy publication), and in part due to variations in efficiency, resulting from various specific procedures.

For journals of commercial publishers, the publisher's profit seems typically to be of the same order as the total production cost (see Appendix, Figure 35). This is understandable in terms of a simple mathematical model, if the publisher tries to approximately optimize his profit and if one accepts other evidence on the dependence of circulation on price (see Appendix, Section IVA.1).

LIBRARY COSTS

The cost of scientific and technical journals to society includes more than the production costs just described, since those journals that go to libraries have to be cataloged, bound, and supplied to users. The increase in costs of these activities when the amount

of journal material available in a library is increased is of the same order as the subscription cost of the added journals, if the latter is computed at current average rates (see Appendix, Section IIID.4).

SOURCES OF REVENUE

Here, too, there is great diversity. Advertising can be an important source only for journals of unusually large circulation. Reprint and back-number sales, though sometimes appreciable, more commonly yield a negligible net of income over cost. The major items of income are usually subscriptions, page charges, and subsidies, both direct (usually from funds of a society) and hidden (donated editorial services, and the like). The practice of imposing page charges has spread rapidly in recent years and seems by now to have been adopted by about half of all journals published in all fields of U.S. societies or other nonprofit groups, though it is more prevalent in physics and chemistry, and somewhat less common in medicine and engineering (see Appendix, Figure 14). The page charge is much less used abroad, even among the relatively rare nonprofit journals. A sizable majority of all articles honor the page charge; the honoring percentage usually increases in the first few years after introduction of the page charge because of education of authors' institutions, but it may fluctuate erratically with fluctuations in government funding.

FOCI OF OPPOSITION TO THE PAGE-CHARGE SYSTEM

In preparing our recommendations on the sources from which the financial support of primary journals should come, we have tried to give careful consideration both to the criticisms that have been leveled against the page-charge practice and to the arguments of its defenders. We shall start by listing some of the points that have been raised most often against page charges and our evaluations of them. Four of these have to do with the basic philosophy of journal support:

1. It is sometimes argued that the financial support for journals should come from those whom the journals benefit, and that this implies that the subscribers should pay for the entire cost of production. We feel that support by those who benefit is usually a sound principle, particularly if their judgments of value received are sound and are able

to influence managerial decisions (see Appendix, Section II). But two things must be borne in mind. The first is that, as we have noted in our previous discussion on the value of journals, subscribers to journals are not the only beneficiaries of their existence; authors and their institutions derive a benefit, to which there are some quantitative clues (see Appendix, Figure 10 and Section IVA.2); the value to future users is quite important (see Appendix, Section IIIC.2), and so is the benefit received indirectly by those who interact informally, verbally or through correspondence, with someone who has used a journal (see Appendix, Sections IIIC.2 and IVA.6). The second point is that it is difficult to make each subscriber pay in proportion to the benefit he receives; often there is a single price for all, and discriminatory pricing rarely extends beyond distinguishing individual from institutional subscribers. As long as this situation obtains, there will be buyers to whom the benefit exceeds the cost of supplying them with an extra copy of a journal already in existence, but is not great enough to justify their paying a price equal to the total production cost per subscriber. Pricing these buyers out of the market can mean a loss to society that most but not all* of us would assess as very appreciable (see Appendix, Section IVB.1). All these considerations make the support of journals by a simple raising of subscription prices somewhat analogous to the support of schools by tuition fees alone: It can be justified only if ways can be found to charge widely different rates to subscribers of different interests and circumstances.

2. A related objection sometimes raised against the page-charge system is that by subsidizing a large part of their costs it lessens the incentive for journals to operate efficiently and relieves them from the "test of the marketplace" that otherwise could weed out uneconomic journals. We feel that the question of economic incentives is a perfectly valid one but that the question should not be so formulated as to prejudge the issue. On the theoretical side (see Appendix, Sections IVA.3, IVA.4, IVA.5), it seems that subsidy of input costs can affect economic incentives in a number of ways, some of which are desirable and some not; there is a diversity of opinions among the members of the Task Group as to the appropriateness of the relative weights assigned to these in the Appendix. On the empirical side, at least two things are clear. One is that market-

*Comment by J. D. Luntz: Extensive research over many years on the readership of journals clearly indicates that the mere fact that an individual or an institution pays for a subscription to a journal does not automatically mean that the journal is read or used. If the price of a journal reflects more accurately its true value to those who make use of the journal, "nonreader" subscribers to that journal may not renew their subscriptions. Loss of such "marginal" subscribers will not be a loss to society.

place pressures are always very ineffective in eliminating uneconomic or undesirable journals (see Appendix, Sections IIIB.1 and IVA.3). The other is that most of the large society journals that now get page-charge support are very efficiently operated when compared to journals of other types, and especially to nonprofit journals that do not have page charges (see Appendix, Section IVB.1 and Figure 35).

3. Another complaint is that page charges are unfair to authors or other institutions if the latter are impecunious or if government support is lacking. Actually, the overwhelming majority of journals with page charges have not discriminated in any way against the publication of papers that do not pay; editorial decisions and billing are done by organizationally distinct groups[17] and usually at different times. Thus about all that can be claimed is that sometimes the nonpaying institutions suffer embarrassment. In our Recommendations that follow (see also Appendix, Section IVB.4), we suggest that this embarrassment be mitigated by education and, sometimes, by substituting for it a real, though in practice quite small, discrimination in speed of publication.

4. An additional complaint sometimes heard is that journals with page charges confront commercial journals with unfair competition. While it is true that opportunities for commercial journals would be wider if page-charge journals did not exist, it is also true that the lower price at which page-charge journals can be marketed provides possibilities for benefit to society that are not available to subscriber-supported journals.* (see Appendix, Sections IVA.1, IVB.1, IVB.4). That the competition, in practice, is not very crippling is indicated by the growth rates of the numbers and sizes of journals of different types (see Appendix, Section IIIB.1), by the extreme rarity of financial failures (see Appendix, Sections IIIB.1 and IVA.3), and by the sizable profit ratios that commercial journals can achieve when they choose to charge a high price (inferrable from Figures 31 and 35 of the Appendix). We grant, however, that it would be advantageous if a practical way could be found to secure benefits for subscribers to commercial journals by providing the latter with page-charge support (see Appendix, Section IVB.4).

Two further points have to do with the rules under which page charges are chargeable to government contracts and with the mechanics of payment:

*Comment by J. D. Luntz: At the same time, there may be a disadvantage to society that results from this. To the extent that there is a reduced "test of the marketplace," the quality of journals may be reduced.

5. The rules laid down in the 1961 statement of the Federal Council[5] stipulate, first, that the page charges "are levied impartially on all papers published by the journal, whether by non-Government or by Government authors," and second, that "payment of such charges is in no sense a condition for acceptance of manuscripts by the journal." In other words, everyone must be asked to pay, but no one required to do so. While the charge that these two stipulations are inconsistent is not quite justified, they do seem a little fuzzy: One is not to "require" payment, but is "levy" to be interpreted as "suggest," "ask," "urge," or "demand" it? Much of the ill feeling mentioned in item 3 arises from the difficulty of choosing the right operating point along this scale.

6. The general cumbersomeness of the system is cause for much criticism.[17] It is very difficult to estimate page-charge requirements in advance, when one is preparing a budget for a research contract, especially since the occurrence and sizes of page charges vary so greatly from journal to journal. We think diversity in the journal population is a good thing but recognize that the budgetary difficulty is a real one, especially for small institutions that rely for their research funds on a very few grants or contracts. (We devote some attention to this problem in our Recommendations.)

CONSIDERATIONS ADVANCED IN FAVOR OF PAGE CHARGES

These can be briefly summarized as follows:

1. Page charges enable journals to have lower subscription prices, hence wider circulations. These wider circulations, in turn, may possibly result in increased utility, though one must be careful to distinguish the social value of a circulation pattern from its mere size. These facts and their approximate economic importance are discussed at length in the Appendix, Sections IIIA.2, IIIC.2, IVA.1, IVA.6, and especially IVB.1; see also Figures 3, 7, and 35. Although we attach considerable importance to this consideration, we do not believe that there would be any danger of journals being unable to raise sufficient revenue from subscriptions to support themselves without page charges. All evidence indicates that for practically all existing journals the total revenue is an increasing function of price up to a level well above the production cost (see Attachment C to the Appendix).

2. Journals whose input costs are largely covered by page charges can adapt much more easily than otherwise to fluctuations in the amount of material submitted to them,

in the market for subscriptions, and to some extent even in unit costs (see Appendix, Section IVA.5). They are much less susceptible to economic damage from photocopying. By being freed from economic dependence on a particular pattern of subscribers to each journal, the community of journals in a given field becomes much more free to experiment with new, and possibly cooperative, user-oriented services (see Recommendations and Appendix, Section IIID.7).

RECOMMENDATIONS

Most of our principal recommendations fall into two groups, the first dealing with national policies for the support of journals and directed largely to government agencies, the second consisting of suggestions for easing the economic problems of journals and directed mainly to publishers or professional societies. We consider these two groups in turn, and follow with a few further admonitions.

The reader will naturally wish to compare our recommendations with those of some of the previous studies we have cited.[2,8,17,20] While our recommendations go into more depth and detail on primary journals than do those of the wider-ranging Weinberg[20] and SATCOM[2] reports, they are entirely in agreement with the general principles enunciated in these reports. Most of the recommendations of The George Washington University report[17] are also similar to corresponding ones of ours. We feel that the central core of policy decisions for the immediate future can safely be made without awaiting still further studies, valuable as the latter will be for continued guidance in the future.

NEED FOR FEDERAL SUPPORT

In regard to support, we feel that governmental subsidy of a significant part of the costs of publication not only is necessary at the moment, but will continue to be desirable for the overall welfare of science and technology in this country for some time in the future. We come to this conclusion because the amount of work, preponderantly government-

supported, that needs to be published is currently so great that in most cases only two of the various sources of income available to journals offer any hope of coping with it: subscriptions and some form of subsidy. Dependence on subscriptions alone does not adequately meet the needs of society for two reasons, which we have already summarized in item 1 (page 10) and items 1 and 2 (page 13) of the foregoing digest of pro and con arguments on page charges. Restated in brief, the first reason is that journals benefit a far wider circle than those currently in a position to become subscribers and that even the direct benefit to subscribers can suffer significantly if the price is too high. The second reason is that a contribution to the support of journals that is proportional to the amount of new knowledge they publish greatly enhances their economic stability in the face of fluctuating conditions and gives them greater freedom to initiate new services for users of information or to cooperate with services that others may provide (e.g., reprography). Nonsubscription support—subsidy—is most appropriately linked to the principle that the support of research and development carries with it a responsibility to make the results publicly available, a principle that has come to be widely accepted by those who have studied scientific and technical communication[2,5,20] and by most administrators in federal agencies (see Ref. 17; Section IVC). While all sponsors of research and development should share this responsibility, it devolves on government especially, as the guardian of the general welfare and the sponsor of most of the nation's research and development work (see Appendix, Figure 17).

The principal channel at present for the nonsubscription support of journals is page charges. Though industry and other sources contribute to them, the principal contribution is from the federal government: Funds from contracts and grants are applied to page charges for papers resulting from government-sponsored work. As we have indicated briefly in our previous discussion of page charges and have documented more fully in the Appendix, this system has been reasonably successful but has shown some weaknesses. In our view the most serious of these, though it is not yet a major problem,[17] is an effect on the author's choice of publication outlet: He may sometimes be so desirous of avoiding page charges that he will choose to publish in a journal that gives inferior service—for example, low circulation—in preference to a better one. As is shown in Sections IVA.4 and IVB.4 of the Appendix, such a decision usually leads to a net loss for society. Another shortcoming we have noted in the present working of the page-charge system has to do with the difficulty of estimating page-charge items for budgets before the research has been done. A shortcoming that at present is more po-

tential than real is that it is in principle possible for a journal to use excessive page charges to support wasteful or dishonest practices. Finally, there is the very real, though psychological, anguish of authors or institutions who are unable to pay page charges; they resent what they call the "pauper's oath."

GOVERNMENTAL POLICIES CONCERNING PAGE CHARGES

Our first recommendation is designed to mitigate the temptations to authors to divert for other purposes money that should be earmarked for publication. We feel that the terms of government grants and contracts should be such as to make such diversion difficult, while leaving the investigator as free as possible to choose among journals and giving him at least some incentive to spend his publication money wisely (see Appendix, Section IVB.4). As a simple measure to promote these ends, we recommend that funds budgeted for publication in a grant or contract should be designated as a "hard" item, not to be employed for other uses without specific approval from the responsible program officer. The latter should be guided by a policy that views unused publication funds as a resource normally to be returned to the agency or to be carried over to fill out the budget of a continuation proposal from the same investigator, a budget that in turn will contain a reasonable item for publication. If this policy is adopted, it should be made clear to investigators that they are expected frequently to have unused publication funds; in this expectation they should be encouraged to budget reasonably liberally for these, especially in the case of small grants or contracts. Applications without a publication item should be accepted only when this omission seems justified.

At this point some may wonder if it would not be better to adopt the more logical and administratively simpler procedure of having government agencies make payments directly to journals, either in the form of page charges for articles reporting sponsored research or as some sort of pure subsidy. This was recommended in Reference 8, and was suggested by many of the authors and editors queried in Reference 17. We ourselves were initially very sympathetic to this approach. More careful study, however, convinced most of us* that we should not recommend it, as it would be likely to entail an undesir-

*Comment by J. D. Luntz: The benefit of direct subsidy versus the hidden subsidy represented by page charges is that, philosophically, the visibility of open support for journals is more socially acceptable. In addition, with direct subsidy, it may be more feasible for requirements to be imposed on subsidized journals to improve their economics and their service to society.

able degree of centralization of control over a major part of the nation's resources for scientific and technical publication (see Appendix, Section IVB.3). We have at the same time spoken with a number of people, both in and out of government, who have a broad perspective on the relation of science and government, and have found a remarkable degree of agreement with this position. It is noteworthy, too, that among the officials of "umbrella organizations" queried in Reference 17, none favored direct governmental subsidy, in contrast to the journal editors, who usually have less political and managerial experience.

The alternative of subsidizing the purchasers of journals, thereby enabling journals to charge higher prices without loss of readership, does not seem to be practical. (See Appendix, Section IVB.2.)

In a second recommendation we would like to combine encouragement of a useful measure that has recently been introduced by some journals with some safeguards against its abuse. This measure—sometimes called the "two-track system"—starts by ascertaining, after acceptance of a paper for publication but before composition, whether the page charges assessed on it will be paid or not. If they are to be paid, processing for publication is carried out as rapidly as possible. If they are not to be paid, the paper is placed in its turn among other nonpaying papers and these are published only as fast as money budgeted for such publication allows. In practice, this may involve no delay in publication or, if too many nonhonoring papers are received, it may result in a backlog with delays for these papers. If the delays are nonexistent or brief, for example, a month or so, the discrimination suffered by the authors of these papers is slight and will not influence them to prefer publication in inferior journals. The loss to society from this short delay of a small fraction of papers will also be slight (see the discussion in the Appendix, Section IVB.4). On the credit side, the journal will gain in financial stability, and honoring of page charges by institutions able to pay will be significantly improved, as a recent experience of the American Institute of Physics seems to show. The legal barrier that prevents some state institutions from paying a nonobligatory fee may also be bypassed. If the delays become long, resentment by authors will rise, as will the loss to society; this loss will be too big a price to pay for the gain in stability of the journal.

Our second recommendation is, therefore, that the government should clarify the conditions under which a two-track system is allowable for journals receiving page charges from federal funds. Journals using a two-track system should be required to

make adequate provision for publishing papers for which page charges are not honored. "Adequate provision" may be defined, at the discretion of the journal, as any one of the following alternatives: willingness to publish such papers up to a specified fraction of the total pages in a year; undertaking to maintain the difference in publication time between honoring and nonhonoring papers—averaged over, say, a year of operations—at less than a specified interval; or, perhaps the publication of nonhonoring papers in a companion journal, identical with the page-charge journal in every respect except for being marketed at a higher price.* In the discussion of the Appendix, Section IVB.4, it is suggested that the fraction mentioned in the first alternative might be in the range of from one fourth to one third and that the maximum time interval mentioned in the second alternative might be of the order of 2 months.

MONITORING

To implement this recommendation it is obviously desirable that some agency of the federal government monitor the operation of journals and maintain an approved list that all agencies can use. The Office of Science Information Service (OSIS) in the National Science Foundation seems to be the obvious choice for this task. We therefore recommend that all nonprofit journals with page charges should be asked to submit to OSIS an annual statement of circulation, costs, and income, with separate listings of bulk and publication time lags for papers that honor the page charges and for papers that do not. Using these data, OSIS should publish a list of journals that satisfy the criteria of eligibility to receive page charges as spelled out in the Federal Council's 1961 statement[5] plus any new modifications that may be made in response to the recommendations of this Report.

The Federal Council's 1961 statement[5] does not explicitly limit the amounts of page charges, but in using the words "page charges are usually calculated as a part of the cost of composition and make-up of journals" it implies that the page charges for an article should not significantly exceed the prerun costs for this article (see the listing of different elements of cost in Figure 8 of the Appendix). For reasons detailed in Section IVB.4 of the Appendix, we think it would be desirable to make this an explicit con-

*Dissent by J. D. Luntz: The two-track system is unfair to both the author and the reader. Both are penalized. This is a major drawback of the page-charge approach to subsidy. And the idea of a higher-priced journal for the papers of authors that do not honor page charges is even more discriminatory against both authors and readers.

dition for a journal to be on the approved list mentioned in the preceding paragraph; the annual reporting of data to OSIS would make it feasible. It should not, however, be interpreted so rigidly as to deny journals the freedom to make changes in page charges quickly, on their own initiative, as this freedom can contribute importantly to economic stability. We do not favor a more explicit ceiling on the amounts of page charges, as this would be difficult to administer fairly—for example, with due account for differences in composition costs of mathematical and nonmathematical material—and might discourage innovations that, while adding to costs, might enhance social value far more (see Additional Recommendations for Societies and Publishers) that follow later in this section.

RECOMMENDATIONS TO PUBLISHERS ON ORGANIZATION AND FINANCIAL POLICIES

Since we have just discussed page charges from the point of view of governmental policies, it is appropriate to begin our recommendations to publishers of journals with a few words on the same subject. First is the question of whether a journal should or should not adopt page charges, and, if it adopts them, how large they should be. We feel that managers of journals have sometimes decided these questions on the basis of emotion without seriously considering the balance of benefits to the scientific and technological community. We recommend that publishers of nonprofit journals weigh these considerations in a manner similar to that outlined in Section IVC.1 of the Appendix. In all cases the journal should adhere strictly to the currently prevailing practice of deciding on acceptance or rejection of papers before learning whether or not page charges will be honored. If it is felt necessary to use a two-track system, the journal should recognize an even greater responsibility than usual to maintain an expeditious publication schedule, so that even papers on the slower track will not suffer delays beyond the range typifying other journals of the same field.

We have several recommendations concerned with management and marketing. Whenever possible, groups of small scientific and technical societies that publish journals with overlapping readership should federate so as to publish their many journals as a single business operation. Such a federation of societies, typified, for example, by the American Institute of Physics, can maintain copy editing, art, advertising, and other departments with well-trained staffs and uniform work loads, can support studies of costs and production methods, and can negotiate effectively with a variety of compositors and printers. We also recommend, in all cases where fluctuations in volume of material

submitted are apt to be appreciable, that journal publishers give serious consideration to offering subscriptions to their journals at a per-volume rate, with an approximately fixed number of pages per volume, rather than at an annual rate.

Finally, we strongly urge all journal publishers to break down their costs into the several types of prerun and the several types of runoff costs (as identified in Figure 8 of the Appendix) and to monitor these individually. Only if these components are known can intelligent plans be made for responding to changing conditions. Moreover, some degree of uniformity in accounting procedures is necessary if really successful monitoring of journal costs by a central agency is to be achieved.

ADDITIONAL RECOMMENDATIONS FOR SOCIETIES AND PUBLISHERS

In our foregoing section on General Perspective, we mentioned many indications that the value of scientific and technical journals, and of communication generally, is many times greater than the cost. We feel that scientists and technologists need to be made more fully aware of this value. Such awareness can mitigate the economic problems of journals by improving the market for them; from a different point of view, it can make a rise in price less harmful to society by lessening its adverse effect on circulation (see the discussion in the Appendix, Section IVB.1). Education, therefore, can help journals give better service with smaller subsidies. Closely related to education is marketing: Marketing techniques need to be more highly developed than they have been, especially by nonprofit publishers. It is the professional societies, however, that bear the principal responsibility: They need to educate their members to a fuller appreciation of the value of information services in general and of journals in particular. This need is especially great in technological fields that have become increasingly scientific.

Just as users or potential users of journals often fail to appreciate their true value, so authors, editors, and publishers often fail to appreciate that, as we have pointed out earlier, the value of the time users must spend to extract from journals the information they need far exceeds the total cost of producing the journals. The implication of this for editors and publishers is that most journals should devote much more thought than they do to improving format and style and to stimulating authors to write more lucidly. Significant improvements in these items may well have enough value to society to justify major increases in technical-editing costs. (See Appendix, Sections IIIC.1, IIIA.4, and IVC.2.) It is worth noting that the Weinberg Report[20] contained a similar recommendation.

We turn next to the technology of printing and composition. We have been impressed by the saving in time and in prerun costs that is currently being realized by journals that use typewriter composition and photo-offset rather than type composition and letterpress (see Appendix, Sections IIIA.4, IIID.1, and IIID.5). We therefore urge journals to consider seriously this and other methods of composition within the production office. From a long-range point of view, it would be of great value if ways could be found to decrease composition costs by a large factor. Not only would this result in a saving of resources, but, perhaps more importantly, it would shift the balance between prerun and runoff costs (as defined in Figure 8 of the Appendix) to a point more in harmony with the relative benefits that producers and users of journal material receive from its publication. This, in turn, would make more natural an equitable distribution of support and control between these two groups.

Our final recommendation to journal publishers, and in particular to scientific and technical societies, is that they should actively explore and when possible implement new ways of packaging and marketing their products that are better adapted to the needs of users and more responsive to users' desires. Such adaptations can range from intelligent subdivision of a journal, when it has become too large to be useful to individual subscribers, to individualized selective dissemination of offprints; intermediate systems may be the most promising of all (see Appendix, Section IIID.7).

FURTHER THOUGHTS

The support policies we are advocating, as well as the recommended improvements in journal management and production, achieve much of their social benefit by making possible low subscription prices. While we have based our advocacy of these policies on consideration for the overall welfare of science and technology in the United States, it is worth noting that they can be extremely helpful to science and technology in the developing countries. Libraries in these countries have a desperate need for journals at low subscription cost. This need can only be met by support policies that make low subscription prices possible or by direct subsidy of export to these countries. All who make decisions that affect prices of journals should reflect on the impact of their decisions on developing countries.

For our final remark we would like to return to a point made in the Introduction: This study has been a hasty one, and the data collected have been sketchy and inadequately

sifted. But we have found even these data very useful in the reasoning underlying the recommendations we have given here. These recommendations could be extended, improved, and continually updated if there were a systematic and continuing effort to collect and analyze such data on scientific and technical primary journals. Such an effort would have a social value far exceeding its cost. We feel that the NAS–NAE Joint Commission on Scientific and Technical Communication, proposed in the SATCOM Report,[2] would be the ideal body to conduct such data collection and analysis because of its flexibility of operation and its close contacts with all the nongovernmental groups that publish and use journals. We recommend that this Joint Commission be equipped to collect and analyze data of this sort.

APPENDIX

A STUDY OF PRIMARY JOURNAL ECONOMICS

Prepared by Conyers Herring, Chairman of

the SATCOM Task Group on the Economics of

Primary Publication

ACKNOWLEDGMENTS

The data of Section III were obtained from numerous sources. Available partial tabulations and other studies appropriate to 1968 conditions were used where suitable. For one large sample, all data obtainable from inspection of journals in a library were tabulated; this tabulation, and much of the later work, would not have been possible but for the assistance of A. J. Herring. Many of the most important data, however, could be obtained only from detailed study of the financial statistics of journal publishers, and we owe a great debt of gratitude to a number of society and nonprofit publishers (see Attachment A) for their cooperation in extracting from their financial and other records the answers to a great many questions we put to them, often with inconsiderately short notice. We also received valuable assistance from several libraries and scientist-editors, and from interviews with many users of journals. Conversations with S. V. Berg have helped clarify some of the theoretical arguments; we are also indebted to Mr. Berg for use of some unpublished statistics gathered by him. Invaluable assistance in the tracking down of previous work and in the final assembling of the material has been provided by Bertita E. Compton of the SATCOM staff.

CONTENTS

	Page
I. INTRODUCTION TO THE APPENDED MATERIAL	31
II. GUIDING PRINCIPLES	34
III. PRESENT SITUATION	43
A. 1968 Data	45
1. Amount of Material Published by Various Types of Journals	45
2. Price and Circulation	52
3. Digression on Elements of Cost	66
4. Prerun Costs	70
5. Runoff Costs	80
6. Page Charges and Other Sources of Income	83
B. Trends with Time	96
1. Number and Size of Journals: Mortality, Birth, and Growth	96
2. Price and Circulation	102
3. Cost and Income	107
C. Use of Journals	117
1. Extent of Use of Journals	117
2. Characteristics of Journal Use	121

CONTENTS (CONTINUED)

Page

III. PRESENT SITUATION (Continued)

D. Further Topics - 131

1. Printing- 131

2. Microform - 134

3. Reprography - 136

4. Differential Costs of Journals to Libraries - - - - - - - - - - - - 138

5. Time Lags and Backlogs- 139

6. National Versus International Tendencies in Publication - - - - - - 144

7. Repackaging and Selective Dissemination - - - - - - - - - - - - - - 147

8. Tax Exemption - 151

IV. ARGUMENTS AND CONCLUSIONS - 153

A. Factors Underlying the Evaluation of Mechanisms for Support of Journals- 153

1. Income and Net Value Versus Price - - - - - - - - - - - - - - - - - 154

2. Decisions and Who Should Have a Voice - - - - - - - - - - - - - - - 161

3. Financial Motivations for Decisions: Role of Buyers- - - - - - - - 164

4. Financial Motivations for Decisions: Role of Authors - - - - - - - 172

5. Stability - 180

CONTENTS (CONTINUED)

Page

IV. ARGUMENTS AND CONCLUSIONS (Continued)

A. Factors Underlying the Evaluation of Mechanisms for Support of Journals (Continued)

6. Underestimation of the Value by Buyers - - - - - - - - - - - 183

7. Noneconomic Motivations- 189

B. Conclusions Regarding Alternative Roles for Government- - - - 191

1. The Alternative of No Support- - - - - - - - - - - - - - - - 193

2. Support through Buyers - 198

3. Support Given Directly to Journals - - - - - - - - - - - - - 204

4. Support through Authors- 207

C. Suggestions for Societies and Other Publishers of Journals- - 219

1. Page Charges - 219

2. Concern for Users- 221

3. Composition and Format - 224

4. Miscellaneous Suggestions- - - - - - - - - - - - - - - - - - - 226

ATTACHMENT A: ORGANIZATIONS AND INDIVIDUALS THAT HAVE CONTRIBUTED INFORMATION USED IN THIS STUDY - - - - - - - - - - - 228

ATTACHMENT B: JOURNAL POPULATION AND SAMPLING PROCEDURE - - - - - - - 230

ATTACHMENT C: MATHEMATICAL STUDIES OF MODELS- - - - - - - - - - - - 237

NOTES - 241

I. INTRODUCTION TO THE APPENDED MATERIAL

The rather large amount of factual and theoretical material in Sections II, III, and IV to follow has been hastily assembled during the few months since the Task Group began its work. Many readers, understandably, will be repelled by the length of this Appendix. But the complication and diversity of the subject matter are such that a significantly shorter study would be likely to overlook some characteristics of journal economics that are sometimes very important, and such a study would certainly not provide sufficient factual support for our recommendations. However, <u>its length should not mislead anyone into thinking this a definitive scholarly compilation</u>. The description of our procedure, given below, should make it clear that our samples were sketchy and that our data were too hastily assembled to be as free of "bugs" as one would like in a definitive study of this important subject. We believe the major conclusions we have drawn from our data to be reliable, but we hope that the very use we have made of these limited data will make clear the value that a more deliberate and continually updated data-collection and operational-research activity could have for future policy decisions by government, societies, and others. Decisions involving large expenditures or long-range commitments, especially, should be backed by more exhaustively researched facts than we have been able to assemble here. Such a thorough and continuing study, advocated in fact in the SATCOM Report[2], could well be a regular activity of the Joint Commission on Scientific and Technical Communication proposed therein.

As indicated in the "Procedures Used..." section of the Introduction to the report proper, we undertook at the outset to formulate some general principles on which one could base decisions on policies for the support of journals and for their operation. Section II sets forth these principles.

In Section III, we present the factual data we have been able to gather. These data were obtained for several different samples of journals, for each of which, usually, only limited types of data were available. These samples were chosen to be typical only of communicators of primary research-front knowledge, a very small subset of the five or ten thousand U.S. journals that might be called scientific or technical in the broadest sense. Within this subset, our still smaller samples were determined to a large extent by their immediate availability; we did, however, make some effort to check for possible systematic differences between different scientific and technical fields, differently motivated publishers, journals of large and small bulk, journals with and without page charges, and the like. Whenever possible, we compared data for our samples with similar kinds of data obtained in previous studies by others. Section III and the associated figures present in detail the data we obtained. (The Table of Contents preceding this Report gives some idea of the types of data collected.) While the data are often much less complete than one would like, we hope that our presentation will give useful indications of the kinds of data that can be of value in future studies.

Concurrently with the collection of data, we tried to determine how various kinds of policies for financial support of journals might be

expected to affect their stability, their utility to potential users, and the effective interplay of value judgments and innovative ideas on the part of all groups having a legitimate concern with communication. These arguments appear in Section IV and are summarized in several recommendations appearing in Sections IVB and IVC; these recommendations, not all of which have been fully discussed within the Task Group, are more detailed and of wider range than those of the Report proper. The final conclusions, and sometimes even the mode of analysis, have depended of course on quantitative characteristics of the data developed in Section III: Not only may an economic model yield different conclusions when different values of the input variables are used, but the very use of a simplified model is only plausible if the things it neglects are indeed quantitatively minor compared with the things it includes.

II. GUIDING PRINCIPLES

At the outset we must recognize that the value of primary journals is measured by what they contribute to the progress of science and technology as a whole. Thus to make recommendations about their economics one should ask two very interrelated questions: If the nation (or the world) devotes a given amount of money and manpower to a certain broad area of science or technology, what proportion of these resources should go into primary journal publication in order to achieve the most progress? Then, given this proportion, what policies controllable by the publishers of journals, and what policies of governmental agencies and other sponsors of research and development toward these publishers, will yield the greatest ultimate progress? In all cases the yardstick is the health and progress of the entire research or development effort, not the mere provision of a "publication outlet" for a given number of papers.

From a long-range point of view this approach, of course, demands attention to the possibility of major changes in our patterns of scientific and technical communication, for example, interactive use of extensive computer stores of textual material. But as our task, as we have interpreted it, is to provide a framework for policies for the immediate future, we shall limit our considerations to journals printed on paper or microform and used by individuals either in libraries or in their own offices; we shall assume that these individuals have work habits not greatly different from those prevailing today and that their employing institutions operate with the present diversity of funding and policies.

With this limitation, let us go on. If the overall health and progress of science and technology are to be the yardstick, who is to be the judge of what contributes to them, and how much? The various entities that now make decisions about information transfer—individuals, university departments and libraries, companies doing research and development, scientific societies, private publishers, government agencies, and the like—base these decisions on perspectives of varying breadth and varying ranges in time, and on motives that involve altruism and self-interest in varying proportions. We believe that the diversity of viewpoints, motivations, and above all of expertise among these entities is a resource that can, if intelligently used, contribute more to the health and usefulness of primary publications than could an extreme centralization of decision-making. As stated in the SATCOM Report[2]: "The management of all scientific-and-technical-communication activities must be as responsive as possible to the needs, desires, and innovative ideas of the scientific and technical groups that they serve. These activities must be sufficiently flexible to adapt rapidly to changes in user needs and communication techniques.... Further, the administrative entities responsible for scientific-and-technical-information programs must be so organized and coordinated that they represent a logical and efficient division of functions, but authority over them must be sufficiently widely distributed to achieve the responsiveness we deem essential." Our interpretation of this principle for the task in hand is that <u>those entities that combine a considerable economic or administrative power with some of the broadest and most long-range points of view—the Office of Science and Technology (OST), the National Science Foundation (NSF), many scientific and technical societies, and others—should set policies that</u>

encourage innovation and freedom of choice by individuals and smaller groups and constrain these activities only to the extent necessary to ensure that the general direction of their choices is not antisocial.

As we have just implied, the factor of freedom of choice impinges on primary-journal economics at two levels. One is the freedom of the individual: He can choose whether or not to subscribe individually to a journal, he can decide whether, and when, to consult a journal in his library or to request that an article be copied for him; he can select the journal to which he submits articles that he writes. More broadly, he can choose his own pattern of acquisition and communication of information, with whatever balance he prefers between oral contacts with colleagues, use of books and journals, membership in societies, and the like. But there are some choices that have to be made by organizations, not individuals. These choices include the decisions of libraries on subscriptions and the decisions of institutions on "institutional memberships" or other support of scientific societies, or on payment of "voluntary" page charges. All these individual and institutional decisions will be affected by changes in policies of governmental agencies, scientific and technical societies, and other institutions; our task is to treat the latter policies as the controllable independent variables of the problem and to estimate from principles of psychology, economics, and other relevant disciplines, how the individual and institutional decisions will respond to them.

Although in practice the decisions just referred to have to be made in an open market, a useful guide to finding policies that will

optimize progress can be provided by a "Gedankenexperiment" in which one supposes that a wise and all-powerful dictator, controlling all publication operations and subsidizing them when desirable out of public funds, negotiates separately the sales of journals to each individual or institution. What policies, that is, what level of subsidy and what terms to the buyers, would such a dictator adopt in order to optimize the progress of science and technology for a given total national investment in them? If we can answer this question, we can then ask how, in a free market where all buyers of a given type must be treated alike, one can most closely approximate this ideal pattern and, at the same time, ensure reasonable economic stability against perturbing influences.

As a concrete illustration of the type of reasoning outlined in the preceding paragraph—typifying, in fact, the main examples we shall consider—let us suppose the following situation. At some time after a program for producing and selling a certain journal has been in operation, the head of the chemistry department at a certain university approaches the dictator and says: "Our department has set up a new research group that will be housed in another building on the edge of the campus. While they will frequently visit the main chemistry building and can use our departmental library when they do, their work would be much more efficient if they could consult the most frequently used journals in their own building. We have studied their patterns of journal use and feel that it would be worth $—— to our program if they could have the following journals available there ——, and $—— more if they could have the following additional ones ——." The dictator then consults his cost figures and

finds that the cost of making an additional copy of each of the journals in the first group, and mailing it to the university, is less than the value figure quoted by the chairman, but that the cost of doing so for each of the journals in the second group is greater than the second value figure. So he replies: "As you know far more than I about the use your group could make of these journals, I will accept your judgment of their value to you, if you are willing to back it up with money from your research funds. As the rest of the nation's economy will not be adversely affected by my giving you these journals at a charge equal to the incremental cost of producing them, I will do so. For the second group of journals, however, you are not willing to pay this much; unless you can convince me that your entire project deserves a greater subsidy than it is now getting, I will not sell this second group of journals to you at a loss." If we grant that the dictator must rely on the department head's evaluation of relative values for his group, and that he must accept the judgment of higher level advisers as to the total amount of the national wealth that should go into chemistry in general and to this department in particular—and if we overlook as he does, the possible benefit that may accrue to people not associated with this department as a result of extra journals here (see Section IVA.6 below)—then we must agree that he has made the optimum decision on journal pricing.

So much for the illustration; we shall return to this particular example in Section IV below. The principle that it brings out can be stated thus: <u>So far as is feasible in our present society, whenever any individuals or small groups are willing to pay a cost at least as great</u>

as the incremental cost of providing some additional information service, it should be possible for them to obtain this service.

The yardstick we adopted at the start of this section—the health and progress of the entire research or development effort—leads to a second important corollary. Namely, we must always keep in mind not only the efficiency of the production and distribution of journals but also the value of the time spent by the users of primary journals in extracting from them the information they need and the time that potential users may waste through not making contact with information that would help them. These are far from trivial factors. As we shall see in Section IIIC.1, studies of typical fields show that the time invested by users of primary journals has a dollar value many times the total cost of producing the journals. Thus it is obvious that any policies that can effect even a slight improvement in the efficiency of use of journals can have enough value to society to justify a very large percentage increase in their production cost. Therefore, operational research on users and their behavior must form one of the principal foundations of any intelligent policy on primary journal economics. Although the presently available operational-research results in this area are rather scanty, we shall make what use we can of them in Section IIIC and parts of Section IV.

Although less crucial than the habits of users, the investment of time and effort by authors of scientific and technical papers should not be forgotten. The time spent in the act of writing (as distinguished from doing the work that is written about and from the supplementary calculations or measurements needed to make the account complete) has a

value usually of the same order as the cost of publishing the product. The value of authors' time should be borne in mind in weighing any policy on publications that may force an author into redundant publication or into excessive private correspondence to communicate details that could have been included in a more extensive version of his published work.

As a final corollary of our principle of looking always at the effect of any policy on the entire research and development effort, we should call attention to "hidden costs" that can, if ignored, sometimes make statistics on primary journal economics very misleading[8]. As we shall see in Section IIIA.4, technical editing and refereeing represent a significant item among the economic inputs into the prerun phase of producing a journal. Although editors are often paid, especially by journals published by the larger societies or by private publishing houses, they frequently are not; even when they are, their remuneration may have little relationship to the value of the time they actually devote to their journals. Referees are only rarely reimbursed. Editorial office space and secretarial help are sometimes supplied gratis by the editor's institution. In comparing the costs of different types of journals, all these and similar things must be taken into consideration. Another item that should not be forgotten is the cost of library maintenance and special library services (see Section IIID.4): For example, in weighing different policies on journal production, one should bear in mind that these policies may force different expenditures by libraries for storage, reprographic services, and the like.

In short, we propose to base our arguments and recommendations on two fundamental principles, and on three corollaries that follow from

them (primarily, in fact from the first one). The primary principles are: first, that all policies and programs for the production and support of primary journals be evaluated in terms of their effect on the progress of the entire scientific or technological activity on which they impinge; second, that this progress will be best served by policies that, subject only to very broad constraints, give as much encouragement as possible to initiative and innovation by publishers and as much scope as possible for individual choices by individual and institutional users. The corollaries are: First, every effort should be made to make any small increment in service available to the users just mentioned whenever they are willing to pay the incremental cost of supplying it; second, one should include the cost of users'—and to a lesser extent of authors'—time among the economic factors of primary journals; third, one should not forget "hidden costs" in journal production and distribution. These principles and corollaries will guide our selection of data in Section III and underlie most of the reasoning of Section IV.

A final word of caution: We must remember that practical policies must usually be compromises. One must sometimes acknowledge constraints that limit what can be done. For example, even the two basic principles just enumerated will sometimes be found in conflict with one another, though we are convinced one should always keep them in mind as a guide and recognize any conflict as a conflict of two valid principles. Among the "practical" considerations that must always temper our judgments, two are basic enough to deserve mention here. The first is <u>political feasibility</u>: Can the people whose cooperation is needed to

make a given policy work be persuaded to give this cooperation? The second is stability in the face of fluctuations in economic conditions or whims of influential individuals. We discuss these considerations further in Section IV, especially Section IVB.

III. PRESENT SITUATION

Our first task, obviously, must be to assemble some facts: Arguments about policies have to be based on a realistic understanding of things as they are. It is a monumental task, however, to get a picture of the present status of scientific and technical journals in all fields. These journals are as diverse in their economics as in their content, and there are an enormous number of them. With the short time and limited resources available for the present study, a comprehensive investigation was out of the question, so we resorted to a limited, but we hope meaningful, sampling of journals representative of a number of important types. Attachment B presents some details about the journal population and our sampling procedure.

We decided to restrict consideration to journals satisfying both of the following criteria: reasonably wide circulation, that is, those that would be found in a large proportion of the libraries that could be considered really well-equipped in the field of the journal; and content consisting primarily of articles describing newly found knowledge for use by experts in the field. These criteria, which are similar to those adopted in the 1963 study of Campbell and Edmisten[7], already eliminate 90 percent to 95 percent of the U.S. journals that could be called scientific or technical in the broadest sense. Of the many hundred U.S. journals remaining, and of the comparable foreign ones, we studied several overlapping groups:

Sample (1): All such U.S. journals in the library of the Bell Telephone Laboratories at Murray Hill, New Jersey, and a fraction of the foreign ones there, about 300 journals in all. For these journals,

which constitute a fairly adequate collection in mathematics, physics, chemistry, and electrical engineering, but cover most other areas sparsely, we collected data on bulk of material, subscription price, page charges where stated, occurrence of advertising material, and sometimes other characteristics.

Sample (2): Journals published by or on behalf of 14 U.S. professional societies in various fields, 45 journals in all. For these we collected data, by letters of inquiry, on costs, circulation, and the like, as well as data of the type described under Sample (1) (see Attachment B). Not all answers were complete, however, as it was necessary to press the respondents for quick replies.

Sample (3): Many U.S. and a few foreign journals on which certain types of information were available in compilations made within the last year by others. Older data of this sort were also used in evaluating the historical trends discussed in Section IIIB.

All the foreign journals included in these samples were ones publishing in English, German, or French, the languages most accessible to U.S. readers. Also, in most of the tabulations that follow, journals devoted to English translations of Russian journals are omitted. (Occasionally they are included, and specifically identified, as they form excellent examples of expensive but useful journals.) Journals devoted entirely to review articles were omitted. Though such journals are extremely important, consideration of their economic problems would involve us in further issues beyond those that need to be considered for primary journals.

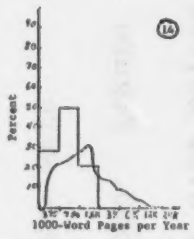
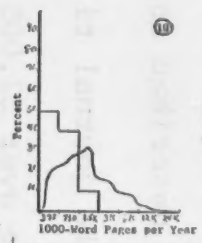
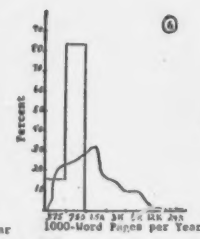
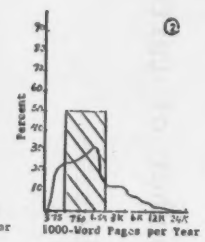
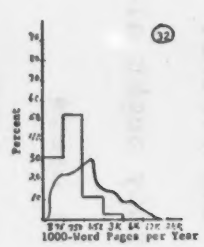
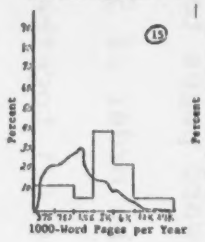
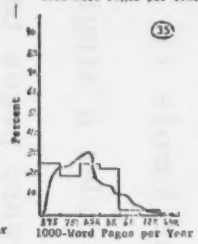
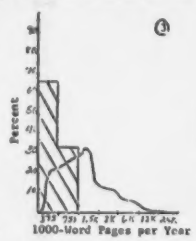
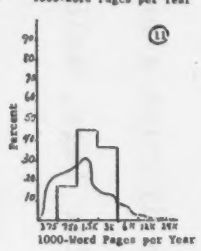
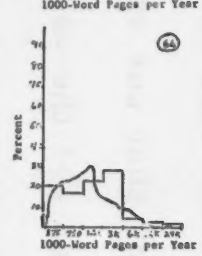
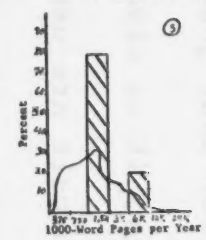
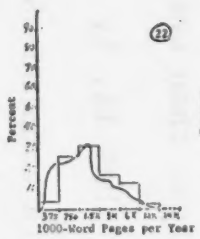
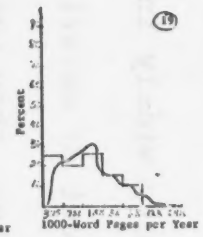
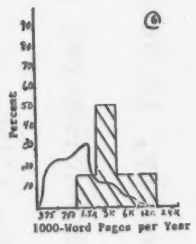
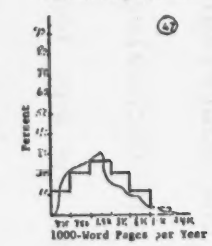
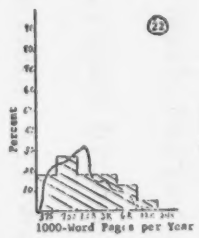
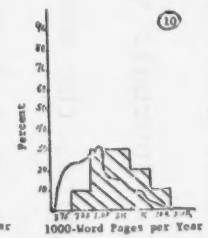
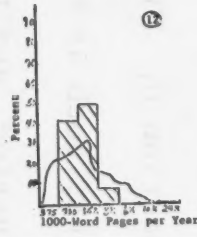
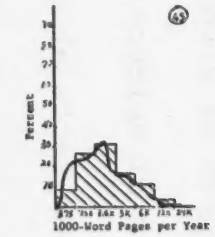
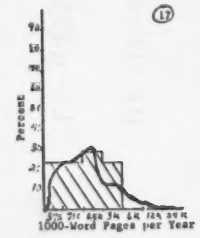
Despite the sketchy nature of our sampling, we obtained a large amount of data that show many interesting features. The basic economic

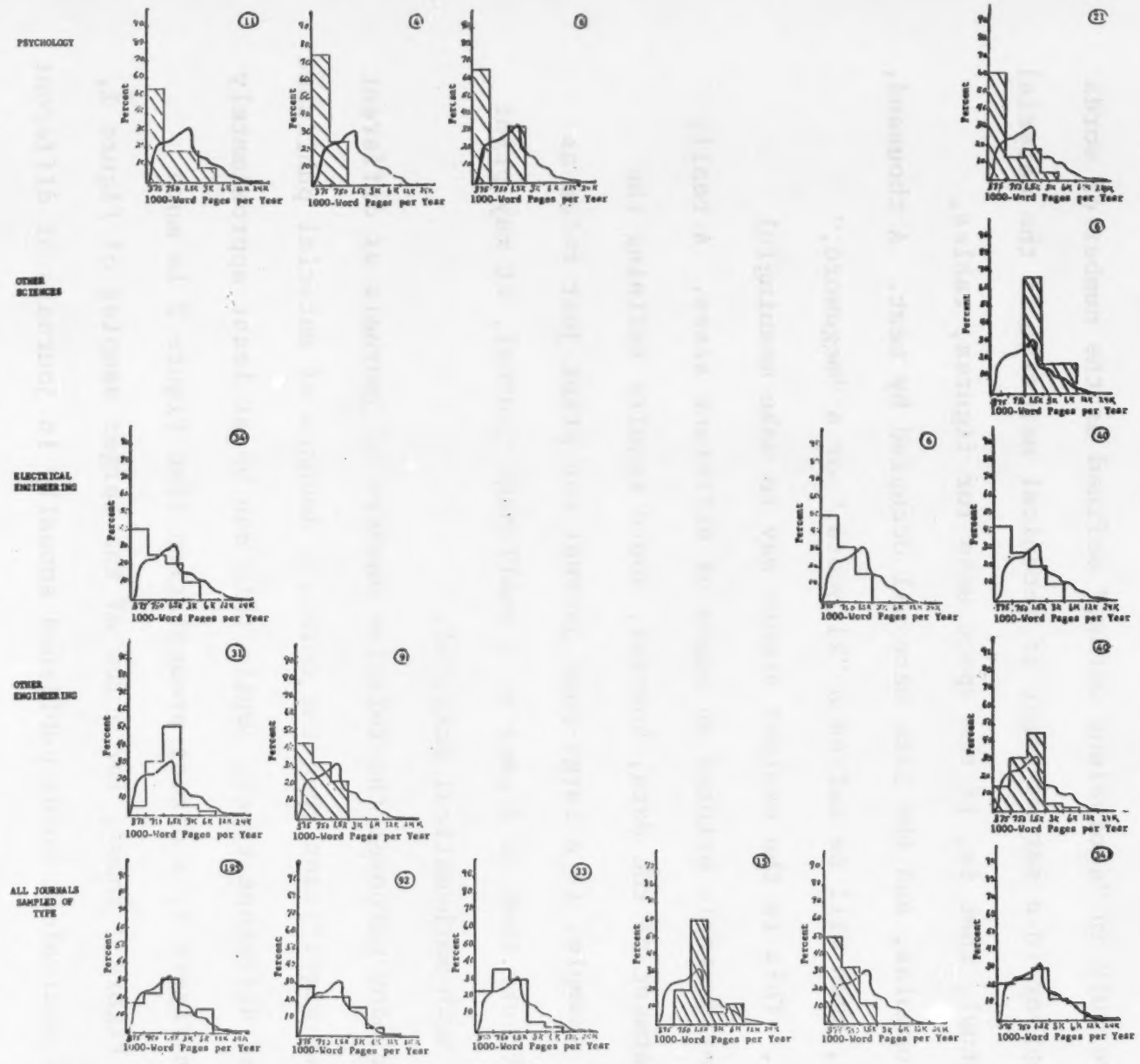
statistics are summarized below in Subsections A and B, together with a few other related items of information; these two subsections deal respectively with 1968 data and with the way journals and their economics have been changing with time. Since we have stressed in Section II that our concern is with the contribution that journals make to the overall progress of science and technology, it is clear that our study ought also to gather facts about the way journals are used and the ways users respond to changes in journals, for example, in their prices. Such facts are harder to obtain than the data of Subsections A and B, but such information as we have been able to get on these topics is summarized in Subsection C. Finally, in Subsection D, we discuss a number of further questions, such as technological prospects, time lags, selective dissemination, and the like.

A. 1968 Data

1. Amount of Material Published by Various Types of Journals

Journals vary widely in size. In our Sample (1) described above, for example, the amount of material published under a single journal title in 1968 varied from less than one hundred 500-word pages to over 22,000 thousand-word pages, that is, by a factor of the order of 500. Figure 1 shows how the journals sampled—Samples (1) and (2) together—were distributed over the various ranges of size; note that the data are less trustworthy in some fields than in others, being sometimes based on small samples. When the samples cover only a fraction of the relevant journals, they are apt to include, for the most part, the larger ones. These data illustrate the wide spread in sizes and show a few other not unexpected features. For example, the largest journals tend to be those published

	U.S. SOCIETIES	PRIVATE PUBLISHERS*	U.S. NONPROFIT (EXCLUDING SOCIETIES)	FOREIGN SOCIETIES AND NONPROFIT**	IN-HOUSE JOURNALS***	ALL JOURNALS SAMPLED IN FIELD
MATHEMATICS						
PHYSICS						
EARTH SCIENCES						
CHEMISTRY						
BIOLOGY						
MEDICINE						



*U.S. and foreign publishers are lumped together here, as there seems to be little systematic difference between them.
**No data are included for Communist countries.
***Journals published by industrial, government, or other organizations, primarily for the reporting of their in-house research.

FIGURE 1 Distribution of journals of Samples (1) and (2) with respect to amount of material published in 1968. Each histogram shows the percentage of sampled journals in a given field and with a given type of publisher whose annual publication of research material lay in various ranges, 1/2N to N, where N is given at the bottom in units of 10^6 equivalent words. Purely to facilitate comparison, each histogram has superposed on it a curve, the same for all, drawn to represent the heights of the bars for the total sample, as shown in the lower right-hand corner. The number of journals in each portion of the sample is shown circled in the right-hand corner of each histogram. Cross-hatched bars are used for the less complete and less representative samples.

by societies, the smallest those published by nonsociety, nonprofit groups; mathematics, psychology, and electrical engineering journals tend to be small, physics and chemistry journals large.

In this Figure, and henceforth throughout this Appendix, we shall measure bulk in "equivalent words," defined as the number of words that would appear in a set of pages of technical material if the material were all textual, that is, if the space used for figures, tables, equations, formulas, and the like were all occupied by text. A thousand, or a million, such will be called a "kiloword," or a "megaword," respectively. This is the easiest simple way to make meaningful comparisons of journals printed on pages of different sizes. A really accurate treatment of the data, however, would require refining the concept; for example, if a large-page journal can print just twice as many words of pure text on a page as a small-page journal, it may print 2.5 times as much mathematical material.

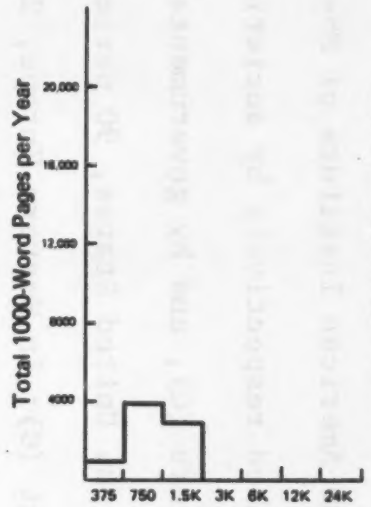
For many purposes the relative numbers of journals of different types are less significant than the relative amounts of material published in journals of different types. While this can be at least approximately inferred from Figure 1, a direct presentation like Figure 2 is more convenient. Figure 2 shows, for a few of the larger samples of Figure 1, the number of equivalent words published annually in journals of different size ranges. Although some of these samples doubtless underestimate the contribution of small journals, it is fairly clear from the two figures that in some fields (physics, chemistry, some areas of biology) the larger journals (e.g., above three megawords per year) publish the bulk of the material, but that in other fields (mathematics, psychology,

many areas of biology and of engineering) the reverse is the case. Thus we cannot do even approximate justice to all fields without giving attention to both large and small journals.

Even more important than the distribution between large and small journals is the distribution of published material between journals of different types of publishers. This cannot be adequately inferred from the circled numbers and size distributions of Figure 1, because the samples used included many foreign journals in some fields but very few in others. For U.S. journals one can use the 1962 figures of the Campbell and Edmisten report[7] (their Tables 1 and 6). These indicate that in every field a great preponderance of the material published domestically appears in society journals; specifically, the percentage of total kilowords in the type of journals they considered appropriate for their study varied from about 90 percent in physics to about 70 percent in biology. For journals published abroad, however, the distribution is very different: In Western Europe, commercial journals publish most of the material, while in Eastern Europe, of course, practically all publication is government operated. For example, according to figures compiled by the American Institute of Physics, the percentages of physics material published respectively by societies or universities (S/U), by commercial publishers (C), and by governmental or quasi-governmental agencies (G) are: in the United States, 90 percent (S/U), seven percent (C), and three percent (G); in Western Europe, 25 percent (S/U), 72 percent (C), and three percent (G); in Eastern Europe, two percent (S/U), 0 (C), and 98 percent (G); in the rest of the world, 67 percent (S/U), five percent (C), and 28 percent (G).

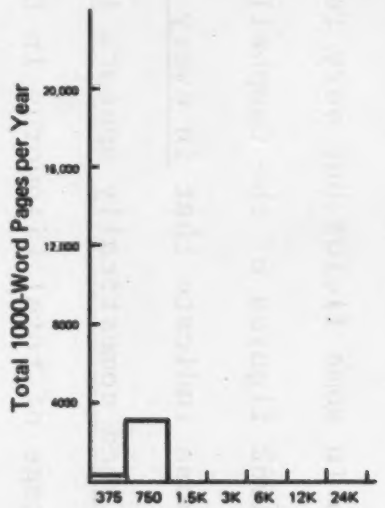
MATHEMATICS

U.S. SOCIETIES



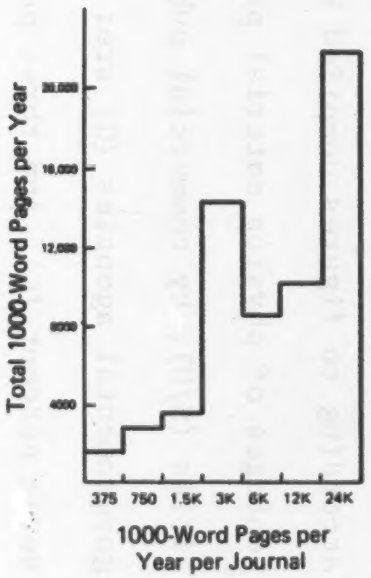
U.S. PRIVATE PUBLISHERS

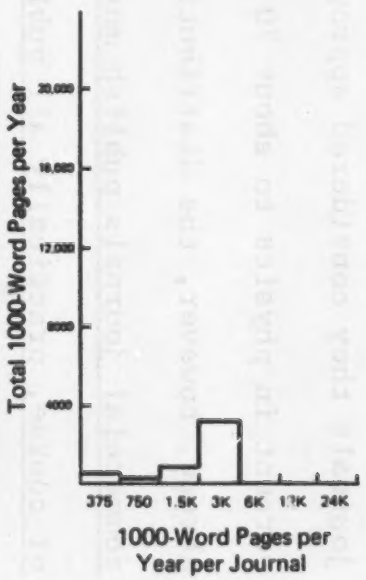
U.S. NONPROFIT (EXCLUDING SOCIETIES)



IN-HOUSE JOURNALS

PHYSICS





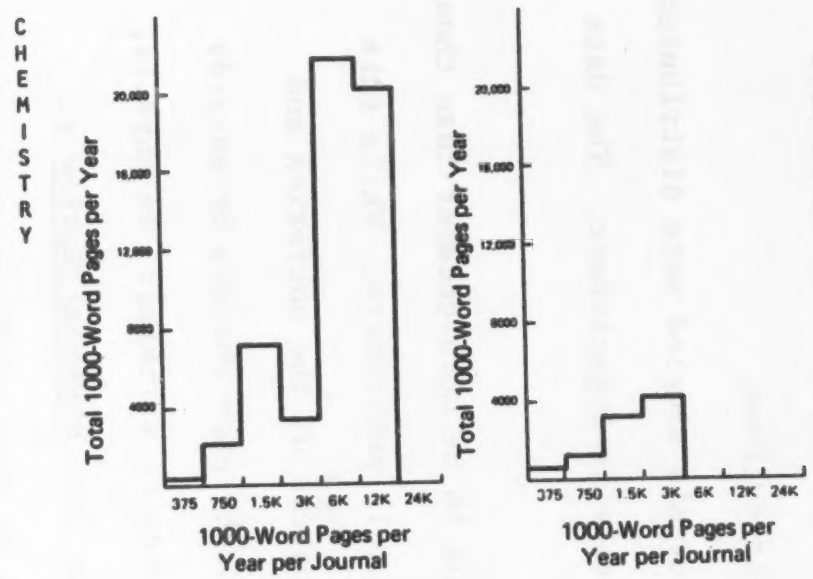


FIGURE 2 Total amount of material published in journals of various size ranges, fields, and types. Vertical scales are in millions of equivalent words. Each bar represents all material published in journals with an annual bulk of 1/2N (or zero) to N equivalent words, where N is given in millions by the number under the bar. Data are for the samples described in the text and in Figure 1; the fraction of the relevant literature covered by the samples is roughly indicated on each diagram.

2. Price and Circulation

There is also a very wide spread in price between different journals. Comparison of journals is complicated by the fact that many journals published by societies are offered to members of these societies at a price below that charged to others, or are even given automatically to all who pay dues. Even nonsociety publishers sometimes discriminate in price between institutions and individuals. United States postal regulations limit such discrimination to a factor of two, for second-class mailing in the United States. European publishers, however, sometimes have the institutional rate as much as ten times the individual. Since much of the discussion in Section IV will involve the effects of different policies on relative availabilities of journals in libraries or other institutional collections, most of the charts to be shown here will be in terms of the price charged to institutions.

Figure 3 shows how the various journals sampled were distributed in price. As in Figure 1, the horizontal scale is logarithmic. The data show several conspicuous features:

(i) Journals published by societies tend to be much cheaper than those issued by private (i.e., for-profit, commercial) publishers. While this is to be expected because of the nonprofit nature of the societies and frequent support of a large part of the costs by page charges or subsidy from society dues, the extent of the difference is striking: In physics, for example, the cheapest society publication (the Physical Review at 0.23 cents per 1000 words) gave ninety times as many words per cent as one of the newer privately published (i.e., commercial) West European journals.

(ii) Journals published by companies or government agencies to report their own work are also very cheap; this is natural, since they are usually substantially subsidized.

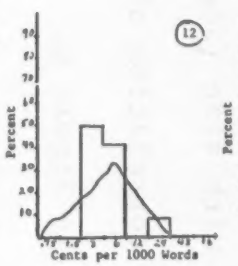
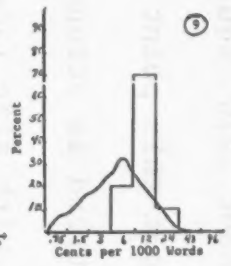
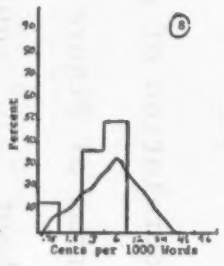
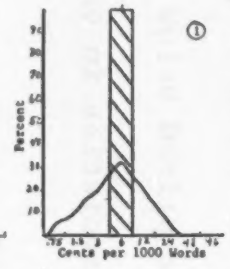
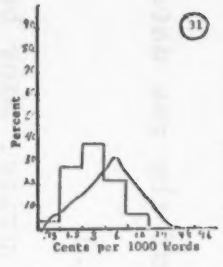
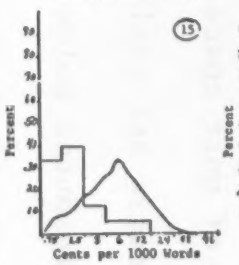
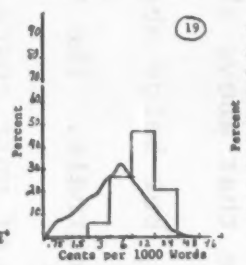
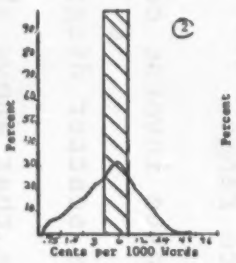
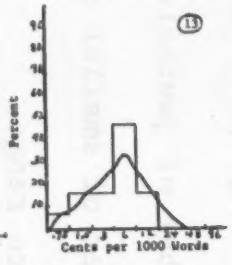
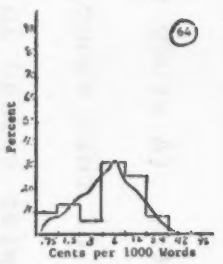
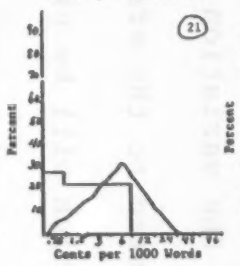
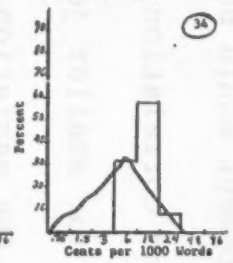
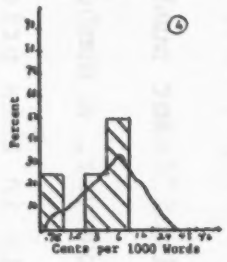
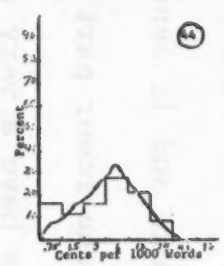
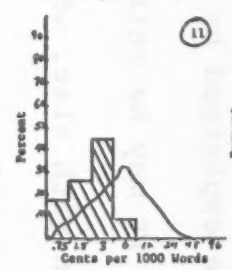
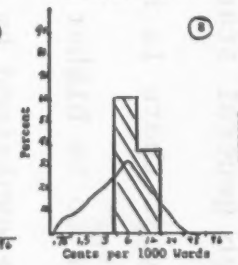
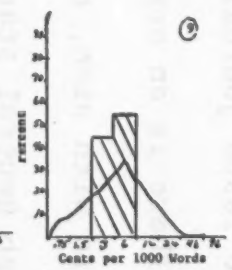
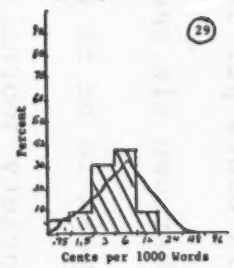
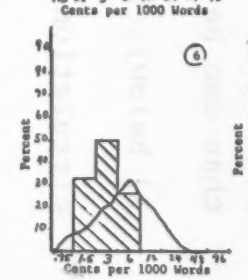
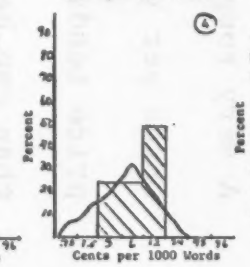
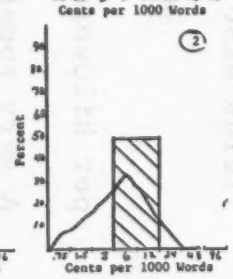
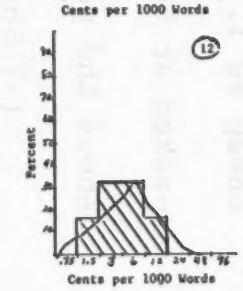
(iii) Journals published by nonprofit organizations other than societies (e.g., university presses) tend to be intermediate in price.

(iv) The journals of private (for-profit) publishers never get as cheap as 1.5 cents per 1000 words, and in nearly all fields are sharply peaked at between six cents and 12 cents. (A study of the raw data shows the peak to be in the lower part of this range.)

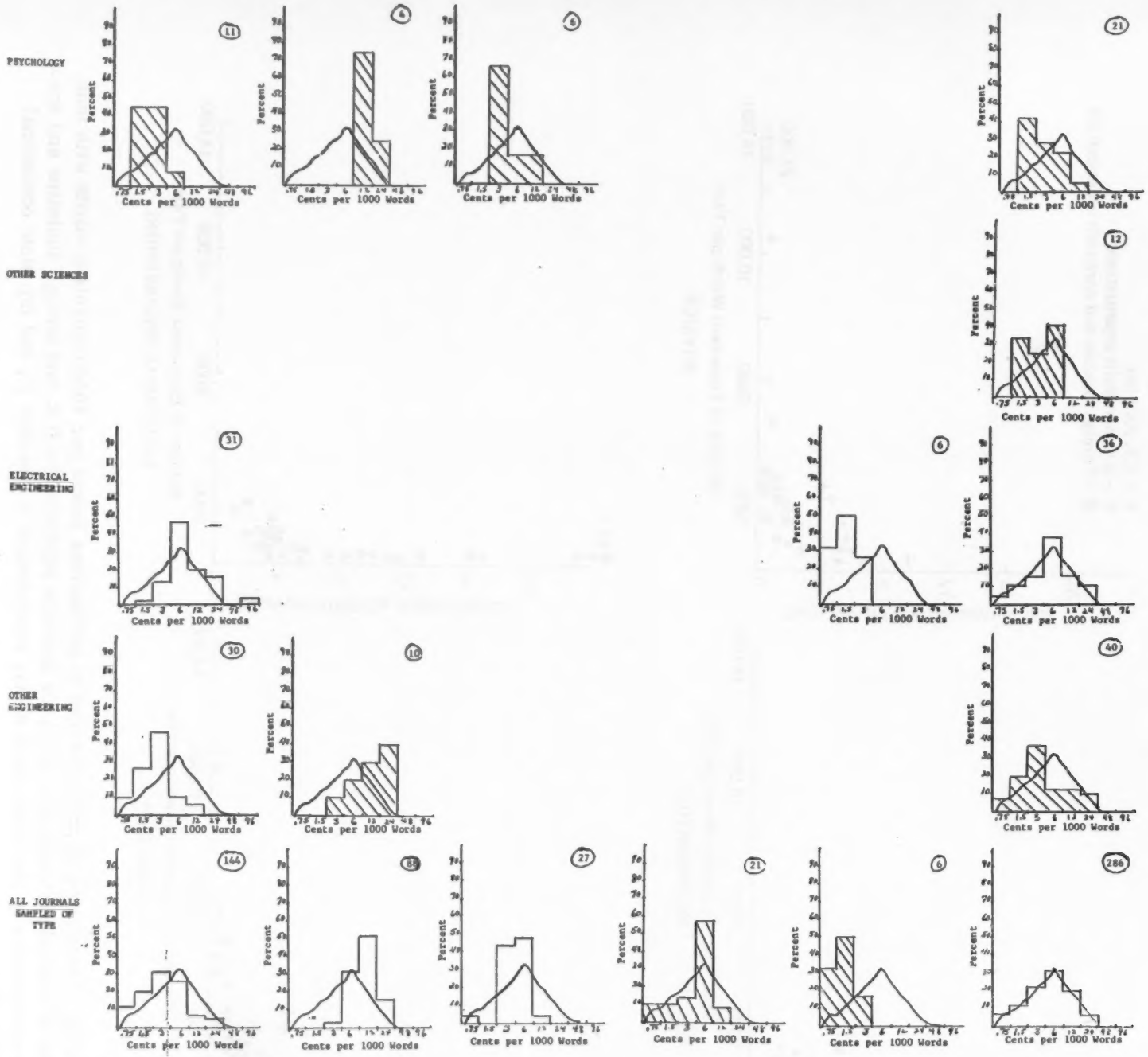
(v) Society journals have a very wide spread in price, many being very cheap but many overlapping the range of the privately published journals. Physics and chemistry, two fields in which societies or society groupings engage in especially large publishing operations, are noteworthy in having a significant number of journals priced below 0.75 cents per 1000 words. However, a number of smaller societies in various fields also issue journals in this price range.

There is an erratic but definite inverse correlation of price per kiloword with size, as shown by the scatter diagrams of Figure 4. A very rough general statement would be that above about 2×10^6 equivalent. words per year there is no correlation, but below about this point the price tends to be higher for smaller journals. The trend is stronger than can be explained by the variation of unit costs with size (see Figure 11 below); it may be related to the erratic but real correlation of circulation with size, which will be presented below in Figure 6.

Circulations vary widely and depend on many factors. Foremost of these is the number of workers in the field of the journal. The quality of the journal and its price are also important. Unfortunately, circulation figures are available to us only for a much smaller sample of journals than those in Figures 1 to 4, namely, those of Sample (2),

	U.S. SOCIETIES	PRIVATE PUBLISHERS*	U.S. NONPROFIT (EXCLUDING SOCIETIES)	FOREIGN SOCIETIES AND NONPROFIT**	IN-HOUSE JOURNALS***	ALL JOURNALS SAMPLED IN FIELD
MATHEMATICS						
PHYSICS						
CHEMISTRY						
BIOLOGY						
MEDICINE						

All figures: Percent vs. Cents per 1000 Words

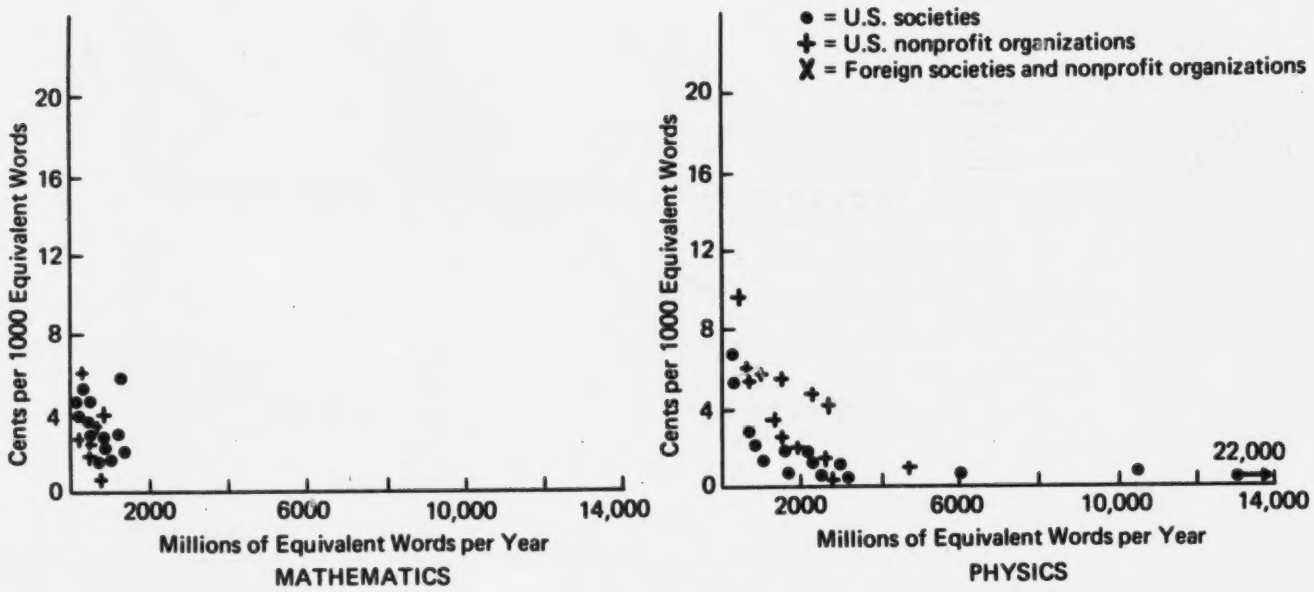


*U.S. and foreign publishers are lumped together here, as there seems to be little systematic difference between them.

**No data for Communist countries are included.

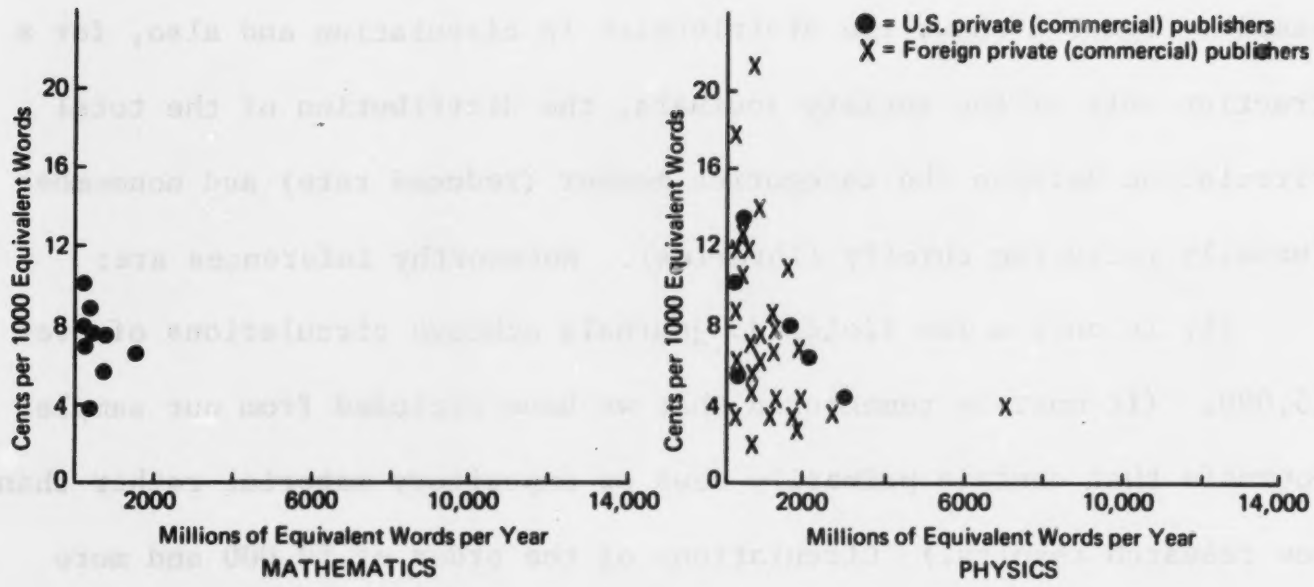
***Journals published by industrial, government, or other organizations, primarily for the reporting of their in-house research.

FIGURE 3 Distribution of journals of Samples (1) and (2) with regard to price charged to U.S. institutional subscribers in 1968. Each histogram shows the percentage of sampled journals in a given field and with a given type of publisher whose prices in cents per 1000 equivalent words lay in various ranges, 1/2N (or zero, for the leftmost bar) to N, where N is given at the bottom. Purely to facilitate comparison, each histogram has superposed on it a curve, the same for all, drawn to represent the heights of the bars for the total sample, as shown in the bottom-right histogram. The number of journals in each portion of the sample is shown circled in the right-hand corner of each histogram. Cross-hatched bars are used for the less complete and less representative samples.



A

FIGURE 4A Correlation of price charged to institutions (cents per 1000 equivalent words with bulk (millions of equivalent words per year) for journals published by U.S. and foreign societies and nonprofit organizations in the fields most highly represented in Samples (1) and (2). Note occasional points off scale.



B

FIGURE 4B Correlation of price charged to institutions (cents per 1000 equivalent words) with bulk (millions of equivalent words per year) for journals published by U.S. and foreign private (commercial) publishers in the fields most highly represented in Samples (1) and (2).

described at the start of Section III (and in Attachment B), and for about 90 others. In particular, few circulation figures are available for privately (i.e., commercially) published journals. For this very limited sample, Figure 5 shows the distribution in circulation and also, for a fraction only of the society journals, the distribution of the total circulation between the categories member (reduced rate) and nonmember (usually including chiefly libraries). Noteworthy inferences are:

(i) In only a few fields do journals achieve circulations of over 15,000. (It must be remembered that we have excluded from our samples journals that contain primarily news or expository material rather than new research results.) Circulations of the order of 50,000 and more occur for numbers of journals in medicine (not shown in the Figure), especially those with a clinical orientation. In chemistry, only the all-encompassing Journal of the American Chemical Society and the inexpensive and applications-oriented Analytical Chemistry exceed 15,000. Occasionally a journal in a populous area of engineering, such as IEEE Transactions on Power Apparatus and Systems, may rise above this figure.

(ii) Relatively few journals have circulations below 1500. Except in biology, most of the journals of our sample in this range were either European journals (usually nonprofit, and often from small countries) or U.S. translations of Soviet journals. Probably journals issued by private (i.e., commercial) U.S. publishers usually exceed the 1500 figure, as publishers acknowledge that they cannot be made to pay at circulations below about 1000.

(iii) Often half or more of the total circulation of a society journal offered to members at a reduced rate falls in this "member"

category. (According to the more extensive 1959 data of Stewart[10], a sizable majority of society journals in all fields were at that time given to members either on dues or at a reduced rate.)

The correlation of circulation with size is very erratic, as shown in Figure 6. The larger journals never have small circulations, but small journals sometimes have large circulations.

One of the most important and least understood relationships in the whole field of journal economics is the dependence of circulation on price. Most of the theoretical arguments about economics to be given in Section IVA below will involve the function n(p), the number of subscribers to a journal when it is marketed at price p, it being supposed that all other characteristics of the journal (bulk, quality, and the like) are held fixed as p varies. There are two possible sources of direct information about this function, neither of them satisfactory:

(i) One is the variation of circulation with time in response to a change of price. Unfortunately, these changes are usually small, and the effect of the price change is apt to be masked by time changes in other factors (size of journal, general level of activity in the field of the journal, status of competing journals). Moreover, the response of subscribers is apt to be delayed.

(ii) The other is the comparison of journals that differ in price, but are otherwise similar. The difficulty here is in being sure that they are "otherwise similar." Even journals with the same distribution of subject matter can differ in their attractiveness to subscribers because of differences in size, nationality of contributors, tradition, and the like.

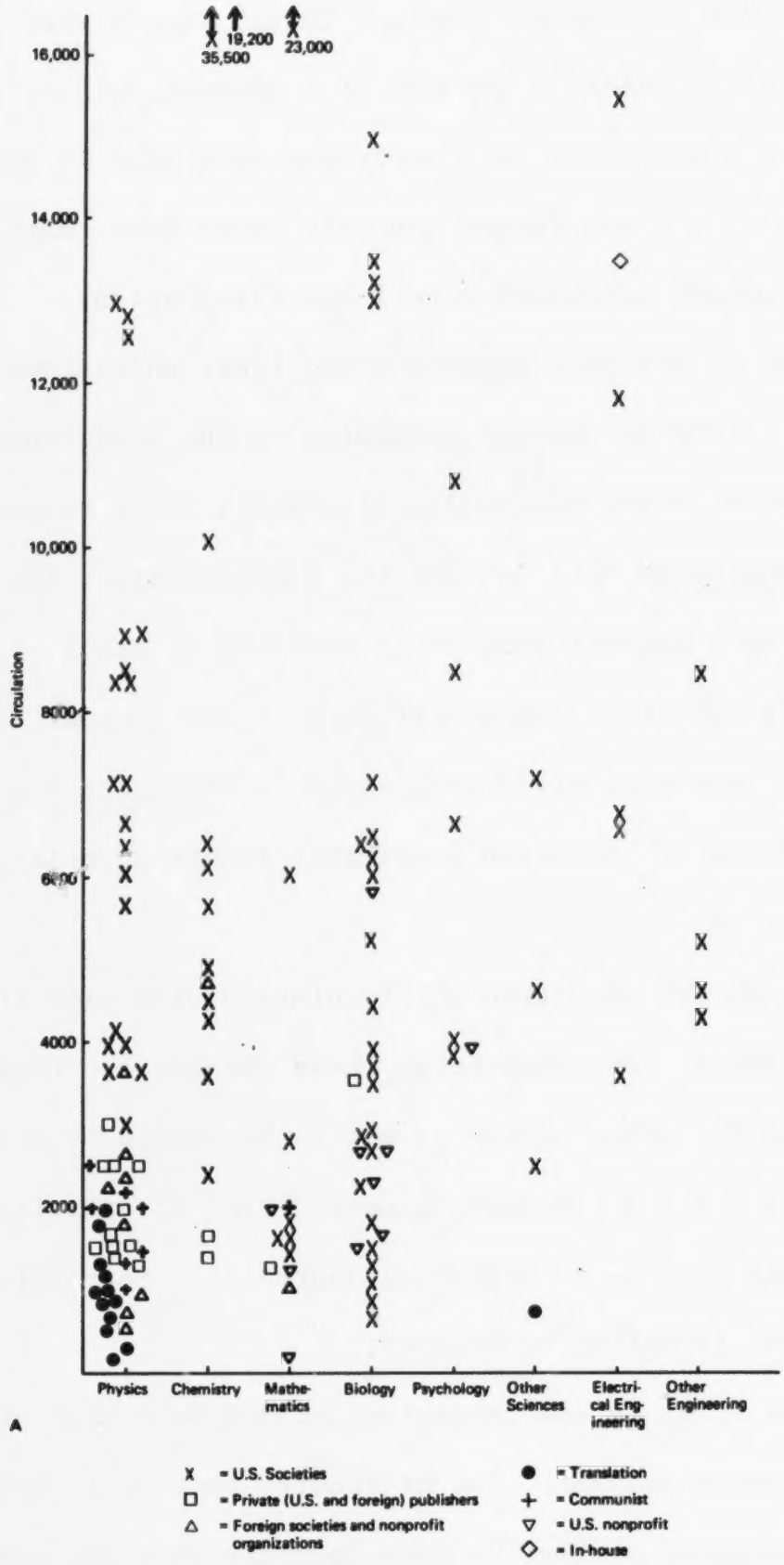


FIGURE 5A Circulations of typical journals in various fields.

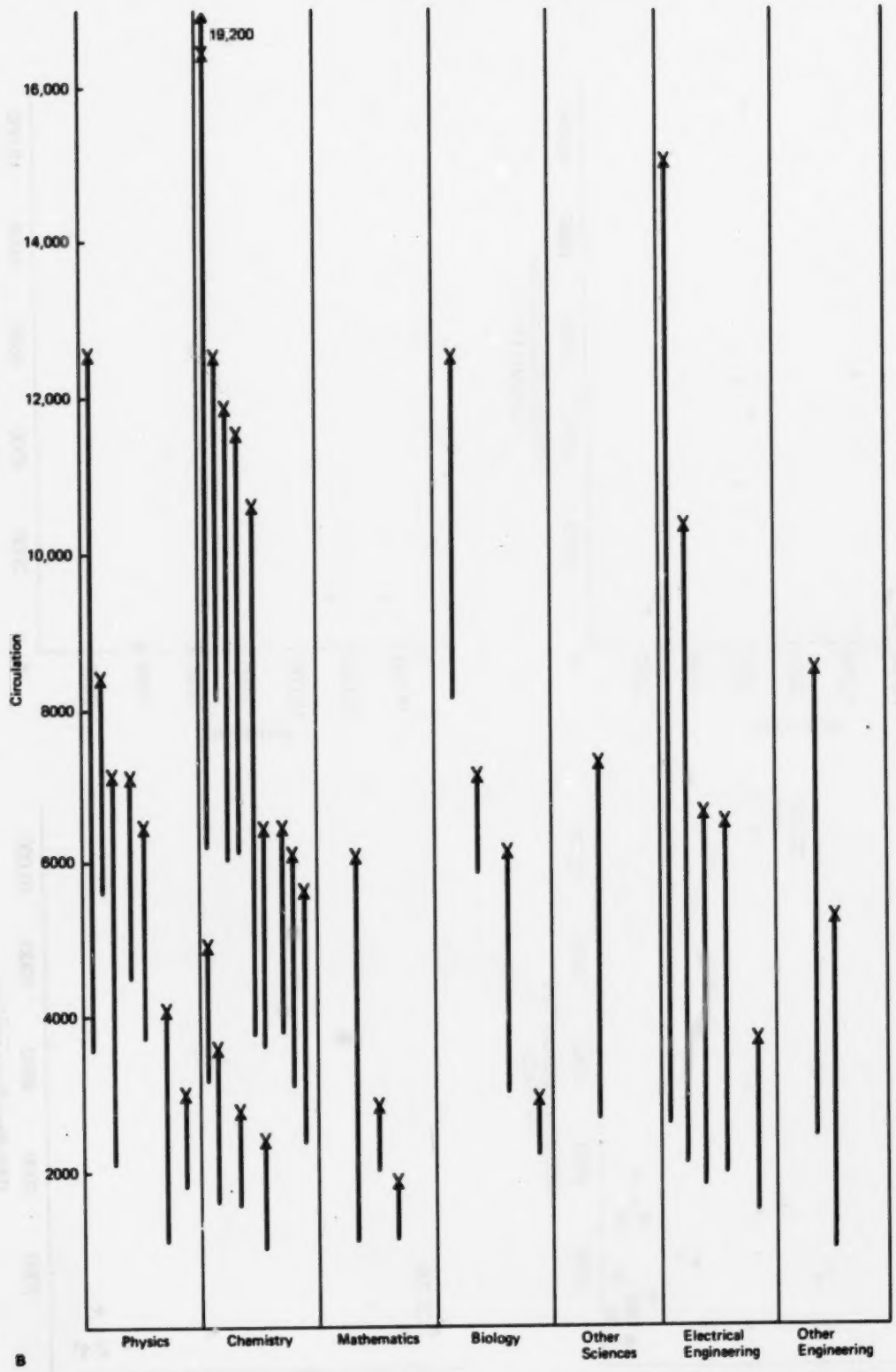


FIGURE 5B Circulations of a sample of U.S. society journals in different fields. For those journals for which figures were available to us, we have drawn a vertical line running downward from X representing the total circulation, which length represents the number of subscriptions sent to society members at a reduced price. Thus, the ordinate of the lower end of this line represents the number of nonmember subscriptions.

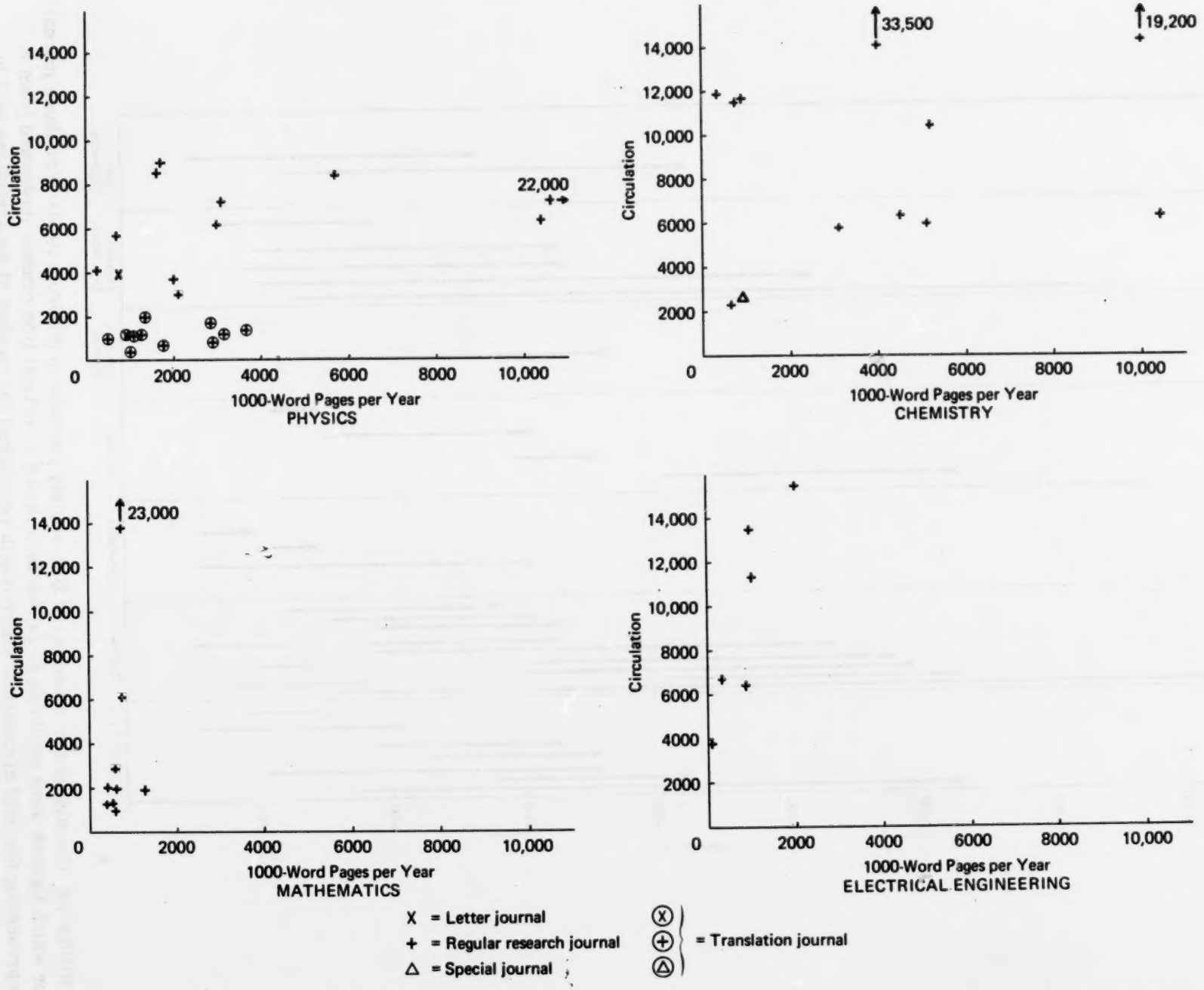


FIGURE 6 Scatter diagrams of circulation versus amount of material published for journals in the most populous fields of Sample (2) (as defined in Section III) and a few others.

Figure 7 shows some scatter diagrams of total circulation against price charged to U.S. institutions. For most fields, the subject-matter areas of the various journals for which we have obtained circulation figures are too diverse for such a scatter diagram to be worth plotting. In physics and mathematics, however, there is a little more uniformity. Here, despite the wide scatter, there is clearly an inverse correlation of circulation with price. One conclusion that can be drawn with fair certainty is that the n(p) curve for a journal devoted to general basic physics would surely be less steep than the dotted curve drawn through the points for the Physical Review and the translation journal Soviet Physics JETP. These are journals of comparable quality and coverage but of widely different prices; all other factors (e.g., tradition, national prejudice, availability of society-membership subscriptions, availability of JETP in the original Russian) should act to increase the popularity of the Physical Review relative to that of Soviet Physics JETP. A plausible guess at the shape of the n(p) curve for a journal like the Physical Review (a U.S. journal of broad scope and high prestige) is shown by the dashed curve.

The general plausibility of the dashed curve is supported by two further lines of reasoning that invoke the judgment and experience of managers of commercial journals. In our mathematical model (described in detail in Section IVA.1), the publisher maximizes his profit by setting the price p such that $d \log n(p)/dp = -(p-r)^{-1}$, where r is the runoff cost per subscriber as defined in Subsection 3 below. As p is $\gg$ r, this quantity can be satisfactorily evaluated with only a rough knowledge of r. With r $\approx$ 0.4 cents per 1000 equivalent words, the dashed curve gives about 5.8 cents per 1000 equivalent words as the price p_{opt} of maximum profit for a journal of

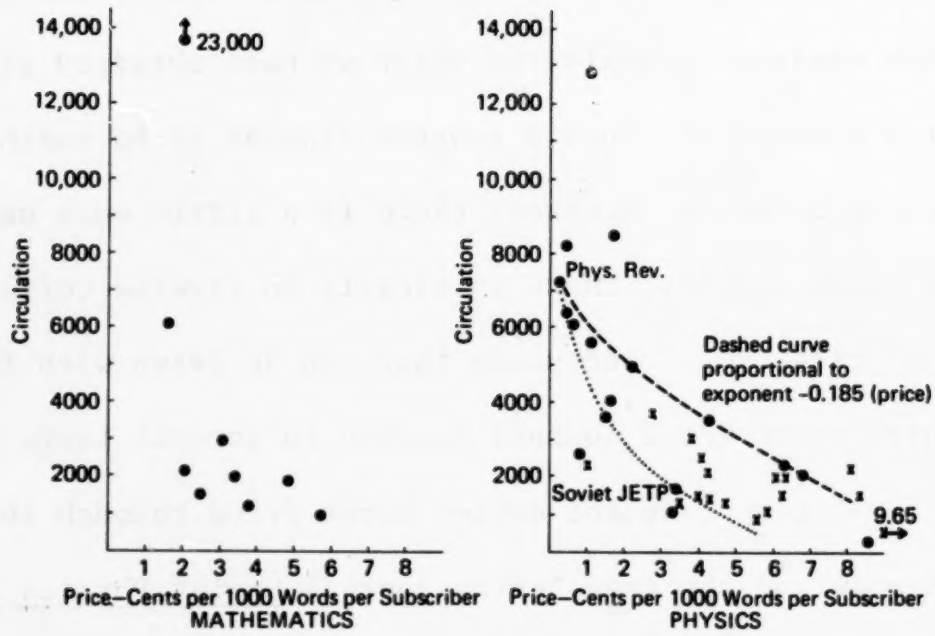


FIGURE 7 Correlation of 1968 circulation with price, for samples of journals in physics, mathematics, biology, and electrical engineering. As occasionally the circulation statistics may be confidential, journals are not individually identified, except for Physical Review and Soviet Physics JETP, which are referred to in the text. The price dependence of the quasi-steady-state circulation of a journal similar to the Physical Review, if marketed at various hypothetical prices, is roughly estimated to be something like the dashed curve and would surely lie well above the dotted curve. It is assumed that, like the Physical Review, such a journal would be provided to APS members at half the institutional price.

this type. As Figures 3 and 4 show, this is somewhere near the centroid of the prices charged by journals published for profit. Inspection of the lists shows that the journals priced significantly higher than this are chiefly European, and with a few notable exceptions are largely rather new journals in very specialized fields. This analysis is of course quite crude: It does not take account of the rather considerable difference, in subscriber response to price, between institutional and individual subscribers, and also the fact that publishers may for various reasons prefer to operate rather below the price of maximum profit. But a more detailed analysis (Attachment C) shows that these factors tend to compensate each other. A different line of reasoning consists in examining the conditions under which a journal becomes commercially impossible. According to the model of Section IVA.1, this occurs when the income curve (depicted in Section IVA.1) fails to rise high enough to intersect the cost curve. As is shown in Attachment C, with typical cost figures the condition that incipient failure should occur at $n(p_{opt}) \approx 1000$—a value quoted by some commercial publishers—implies that the function n(p) has about the same horizontal decay length as the dashed curve of Figure 7, with a lower height.

It is interesting to note that some data obtained from a large university library on the total number of subscriptions to physics journals held by all its sublibraries tended on the average to correlate with price according to a curve very similar to the dashed curve of Figure 7.

The somewhat less complete data of Figure 7 for other scientific and technological fields suggest that curves with a horizontal decay length comparable to that proposed for physics may well be appropriate for them also.

In regard to the approach labeled (i) above, we have not been able to get any convincing evidence from the data on subscriber response to price changes provided us by the publishers with whom we have corresponded. Berg[19] has made a multivariate analysis of data for some journals of the American Chemical Society, from which he has tentatively concluded that d log n(p)/d log p lies between 0 and −0.5, being significantly more negative for the individual-subscription component of n than for institutional subscriptions. As the journals he studied have institutional prices a little below one cent per 1000 equivalent words, the dashed curve of Figure 7 would have a value of Berg's parameter equal to −0.18, in fair agreement with what he found for <u>total</u> circulations.

3. Digression on Elements of Cost

It will be helpful, before we discuss statistics on costs of production of different types of journals, to enumerate the items that make up these costs and to indicate various possible subgroupings of them. One reason it is important to do so is that different organizations handle their cost accounting in different ways, so that in spite of our care to ask for the same items of cost information from all journals, it was not possible for them to supply strictly comparable answers. Therefore, a little orientation about costs will better enable us to allow for the uncertainties in the meaning of the data presented in Subsections 4 and 5.

Figure 8 lists those operations for which costs have to be considered. These are arranged in three columns according to the logical

Location	Prerun Costs	Miscellaneous Costs	Runoff Costs
Editor's Office[a,b]	Technical editing[c]: Salaries of editors Clerical staff Telephone, postage, etc. Referees		
Production Office[a,b]	Copy editing[d]: Copy editors' salaries Clerical staff Art Department Indexes Miscellaneous: Contribution to proofreading Page-charge billing [Typewriter composition[e]]	Promotion Advertising: Solicitation and correspondence Processing of copy News, etc. Handling of reprint and back-number orders	Subscription maintenance
Printer	Composition[e]: Typesetting Proofreading	Back Numbers: Over-run for back-number stock Mailing Reprints	Wrapping and mailing Printing, etc.: Paper Presswork Binding
Engraver	Engravings		

[a] Editor's office and production office may sometimes be operated together.
[b] Note that overhead and employee benefits should be included.
[c] Technical editing includes receipt of manuscripts and all work involved with decisions as to their acceptability, need of revision, etc.
[d] Copy editing, the preparation of manuscripts by the typesetter or other compositor, includes such things as marking them for the compositor, standardizing headings and footnote arrangements, planning the layout of figures and tables, etc.
[e] Typesetting may sometimes be replaced by typewriter composition done in the production office, plus plate preparation done by the printer. Computer photocomposition, again outside the printing house, may also be used.

FIGURE 8 Elements of cost in the production of a journal.

status of the different operations (discussed below) and in several rows according to their geographical location. Their chronological sequence starts with "technical editing," "promotion," and "subscription maintenance" and ends with "wrapping and mailing" and "reprints."

It is the division into columns with which we are most concerned. The left-hand column, labeled "prerun," contains all operations that are necessary before production of the first copy of the printed research or development work that we presume to be the principal content of the journal and its raison d'être. These costs are independent of the number of copies to be produced, but, for a given type of material, they increase with the number of research pages (or of papers) published, and for a sufficiently large operation they are proportional to this number. The right-hand column, on the other hand, the one labeled "runoff," contains operations the costs of which depend on the number of subscribers to the journal, being proportional to this number if it is reasonably large. Most of the runoff costs of course also increase almost proportionally with the page bulk of the journal; however, subscription maintenance—keeping records of subscribers, billing them, and the like—does not, while covers, wrapping, and mailing may do so only in a stepwise manner. The middle column of the figure, finally, contains operations that can be viewed as incidental, rather than as necessary, to the publication of new knowledge and that need be performed only insofar as they are regarded as independently desirable or can be made to yield more income than they cost.

As we have already briefly mentioned in Section II, the full costs of some of these operations do not always appear on a journal's

books, especially if the journal is a small one. A common situation is for the editing of a journal to be a part-time activity of a scientist employed by a university or an industrial laboratory, and for the journal to pay a stipend to the editor and certain expenses incurred by his office, such as telephone and mail costs, and perhaps the salary of a secretary. However, it is rare for these payments to make adequate allowance for the value of space and for other overhead items, and it frequently may happen that the editor's stipend does not even cover the (unloaded) value of the time he devotes to the journal. In such cases the editor's employer is really subsidizing the journal.

Deferring numerical estimates of these hidden costs to Subsection 4, we make here only some general qualitative comments about the costs of technical editing, whether hidden or accounted. One important thing to note is that the time costs of technical editing—in which the major item is the loaded-salary value of the time spent by the editors themselves—depend more on the number of papers handled than on the number of pages published. Thus a letter-type journal, publishing short communications, will, other things being equal, show a much larger figure for technical editing costs per thousand equivalent words than will an archival journal publishing long papers. Also, a journal with high standards that rejects many papers will normally have higher editorial costs per paper published than one that publishes nearly everything submitted to it. Moreover, there can be wide variations from one journal to another in the amount of editorial time devoted to holding authors to high standards of exposition and the like. Thus we need not be surprised to find that the true cost of technical editing is for some journals only

a small fraction of the total prerun cost, while for other journals it is the largest prerun item.

The difficulty of analyzing journal production costs is now apparent. For basic economic studies, such as the one we are trying to make here, one would like to have the costs separated primarily according to the three columns of Figure 8, and only secondarily according to the other subdivisions. Most journal publishers, however, group their expense records primarily according to the geographical locations or organizational entities involved, that is, according to the horizontal strata of Figure 8, and only secondarily according to the functions performed. Thus our requests to journal publishers for the former type of breakdown of costs were not always easy for them to answer and may in some cases have necessitated hasty and arbitrary decisions on allocations of items not normally broken down in this way.

4. Prerun Costs

As Figure 9 shows, the total of prerun costs appearing on the books of scientific and technical journals seems to range from about 40 dollars to about 80 dollars per thousand equivalent words for fields using an abundance of mathematical or chemical symbols and to be slightly smaller for fields in which the material is largely textual. The variations from journal to journal are due to many factors, including the ones we have discussed at the end of Subsection 3, namely, variations in bookkeeping practices and hidden technical-editing costs. (The rare cases where the latter hidden costs do not enter at all are designated in the figure by black dots.) The importance of bookkeeping practices is nicely illustrated by our experience with several journals that,

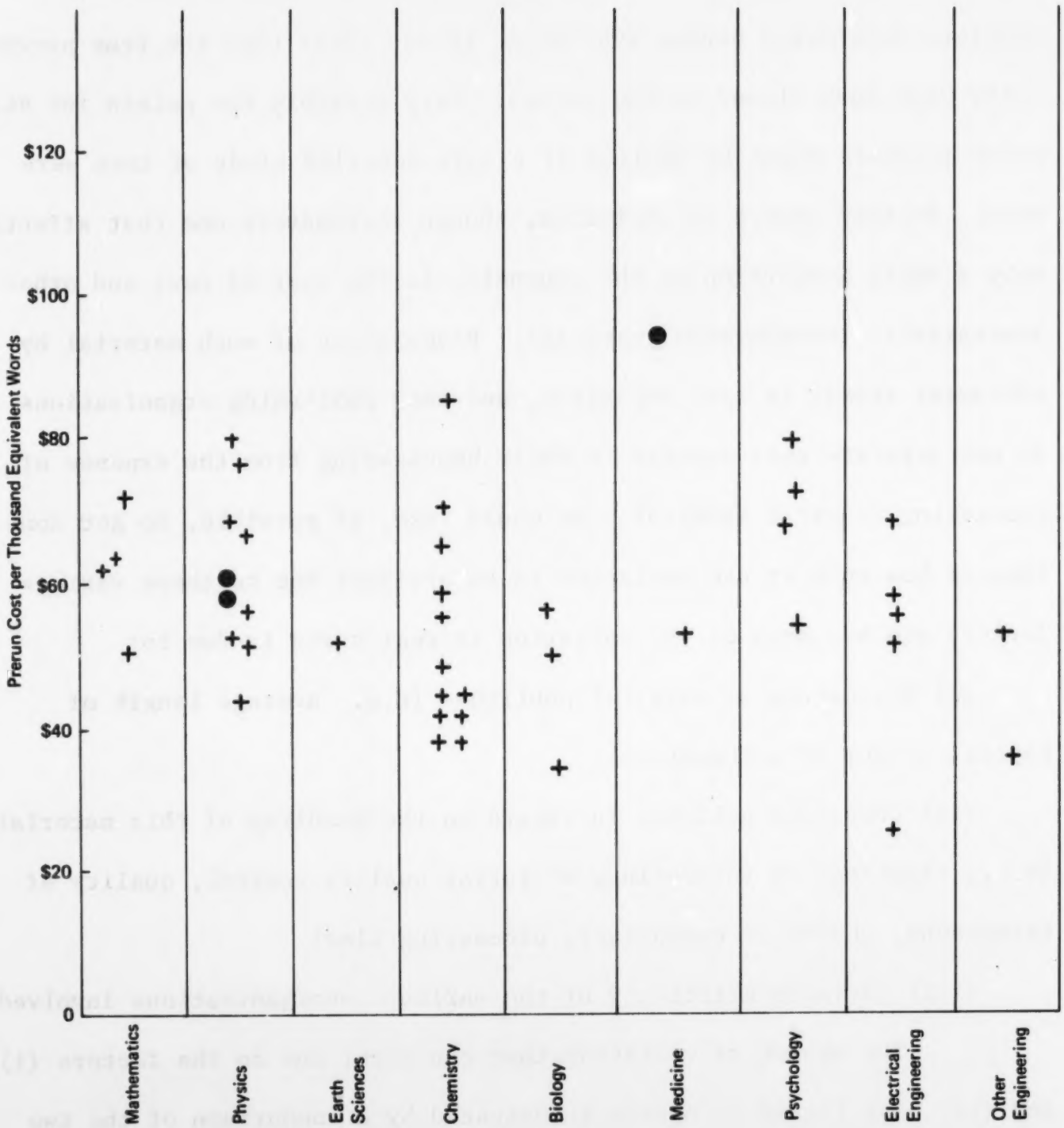


FIGURE 9 Distribution of apparent prerun costs (as defined in Figure 8) per unit amount of material published, as they appear on the books of journals of Sample (2), in various fields. For journals containing advertising or other nonresearch material, the figures are intended to apply to the research material only, but may not always fully realize this intention. Black dots identify journals with full-time paid editors, for which one can be sure that there are no hidden costs for technical editing.

when the plot was first made, were so far outside the range of the others that we wrote them again to find out the reason. When more nearly complete statistics became available, it was clear that the true prerun costs were much closer to the others. Very possibly the points for still other journals might be shifted if a more detailed study of them were made. Another source of variation, though fortunately one that affects only a small proportion of the journals, is the cost of news and other journalistic (nonresearch) material. Preparation of such material by editorial staffs is very expensive, and many publishing organizations do not separate this expense in their bookkeeping from the expense of processing research material. We would like, if possible, to get some idea of how much of the variation is an artifact due to these various factors and how much of the variation in real costs is due to:

(i) The nature of material published (e.g., average length of papers, amount of mathematics)

(ii) Conscious policies in regard to the handling of this material (e.g., tightness of refereeing, editorial quality control, quality of typography, choice of compositor, processing time)

(iii) Variable efficiency of the various suborganizations involved

The amount of variation that can occur due to the factors (i) and (ii) just listed is nicely illustrated by a comparison of the two journals Physical Review and Physical Review Letters. These have comparable bookkeeping procedures, as they are both produced by the same organization, the American Physical Society, though with somewhat different types of assistance from the American Institute of Physics; both have full-time paid editors working at the Society's offices, so

are free from hidden-cost uncertainties. Although the prerun costs per 1000 equivalent words are nearly the same (58 dollars and 60 dollars, respectively, in 1968), the sources of major costs differ greatly for the two publications. Physical Review Letters publishes very short communications very rapidly and receives about twice as much material as it wishes to publish. Consequently, its technical-editing costs per 1000 equivalent words are much higher than those of the Physical Review, which has a lower rejection ratio and publishes longer papers, hence has fewer papers to handle for a given number of words. Thus 1968 technical-editing costs were only of the order of seven or eight dollars per 1000 equivalent words for the Physical Review, but were well over 20 dollars for Physical Review Letters. On the other hand, in 1968 four of the five sections of the Physical Review were typeset, whereas Physical Review Letters was entirely produced by typewriter and photo-offset, a process that reduces composition and copy-editing costs. (Because of its economy and for other reasons, an experimental start has been made in the use of this method of composition for the Physical Review also by applying it to one of the five sections.)

Technical editing. This example suggests that technical-editing costs (often hidden) are likely to be a sizable and highly variable item in the real prerun costs of journals and that it will be important to study them in some detail. Unfortunately, our awareness of this developed only gradually during the short period in which the present study was in progress, and we were able to investigate these costs for only a very small sample of journals, and for for these only in a very crude way. As journals vary widely in the adequacy with which they reimburse editors and their

institutions, and as our interest is primarily in the cost to society as a whole, we have chosen to report our rather sketchy and inaccurate data in the form shown in Figure 10. This is a scatter diagram with editorial (i.e., professionally highly trained) time and secretarial-clerical time plotted on the horizontal and vertical scales, respectively; in the lower diagram these times are referred to unit bulk of material published, and in the upper they are referred to the number of papers published. Note that the letter journal agrees more closely with the regular journals in the upper plot: Editorial costs depend primarily on the number of papers processed, and only secondarily on their length.

To convert time data such as those of Figure 10 into dollars, we must allow for several things. The (unloaded) salary of a technical editor may vary from below 12,000 dollars for a junior scientist or engineer to over 40,000 dollars for a "big name"; that of a secretary or semitechnical assistant from around 4,000 dollars to over 10,000 dollars. The sum of editorial and clerical salaries should be augmented by approximately ten percent for employee benefits, by perhaps 1,500 dollars per man-year for the value of space occupied and for related institutional services (e.g., library facilities), and by slightly smaller amounts for office supplies, postage, telephone, and the like. It can also be argued that the figures for editors' time in Figure 10 should be augmented by a factor of the order of 1.3 or 1.4, because they refer only to time actually spent on the journal. A part-time editor would not usually think of charging to the journal the time he spends attending seminars, browsing the literature, or conversing with colleagues about nonjournal matters. Yet even a full-time editor will

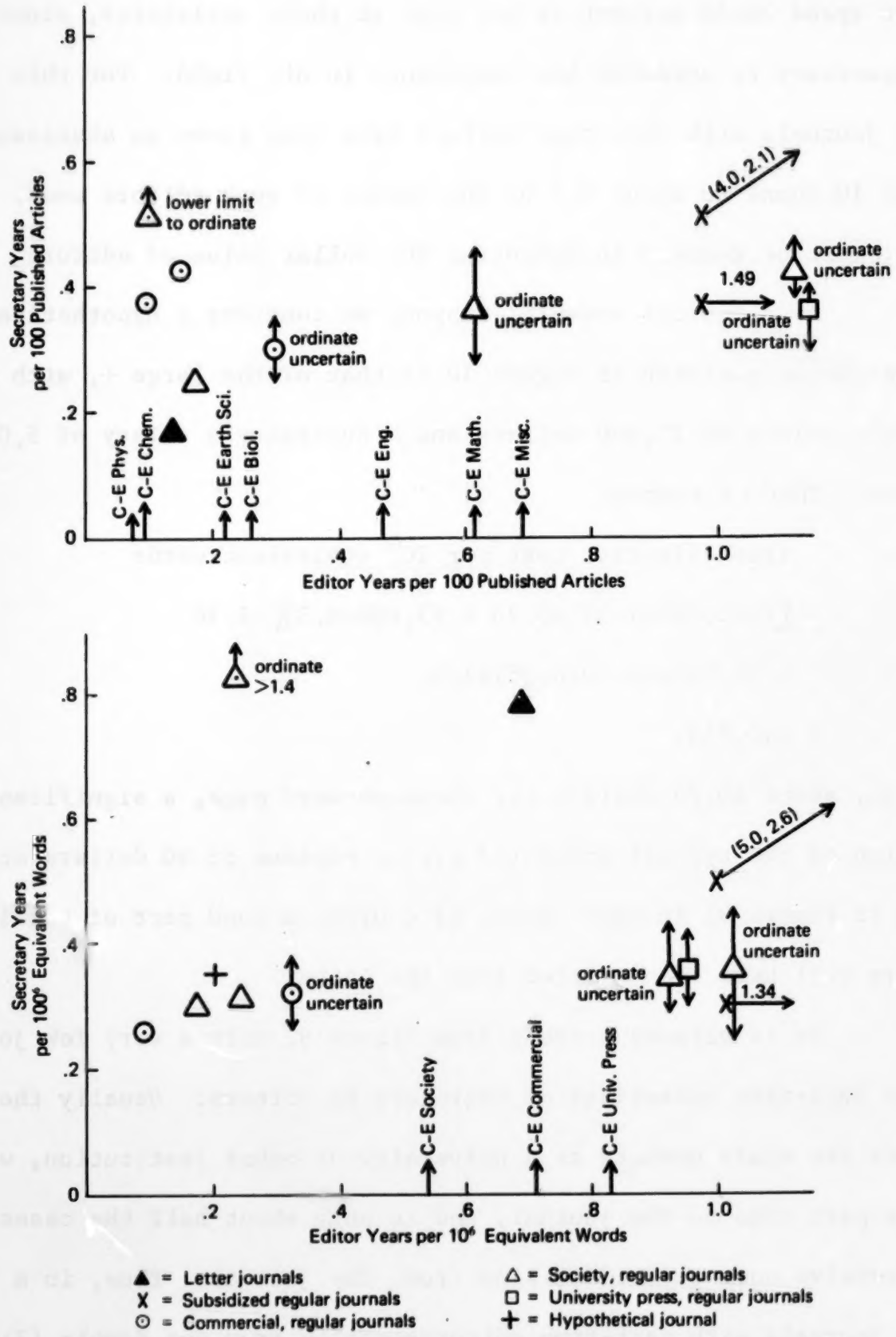


FIGURE 10 Approximate time devoted to technical editing by editors (professional training in field equal to or above M.A. level) and by secretaries, assistants, etc. (not experts in the field of the journal, or B.A. degree training only), for a small sample of journals. Also shown are some average abscissas computed from the data of Campbell and Edmisten,[7] for different types of publishers (bottom of lower plot) and for society journals in various fields (bottom of upper plot).

always spend 20-30 percent of his time at these activities, since they are necessary to preserve his competence in his field. For this reason those journals with full-time editors have been given an abscissa in Figure 10 equal to about 0.7 of the number of such editors used. This factor must be removed in computing the dollar value of editors' time.

As a typical example, suppose we consider a hypothetical journal whose position in Figure 10 is that of the large +, with an editor's salary of 25,000 dollars and a secretary's salary of 5,000 dollars. Then we compute

$$\begin{aligned} &\text{true editorial cost per } 10^6 \text{ equivalent words} \\ &\simeq \left[(\$25{,}000 \times 1.35) \times 0.20 + \$5{,}000 \times 0.35\right] \times 1.10 \\ &\quad + \$1{,}500 \times (0.20+0.35) \times 1.3 \\ &= \$10{,}753, \end{aligned}$$

that is, about 10.75 dollars per thousand-word page, a significant minor fraction of the typical accounted prerun expense of 50 dollars or so shown in Figure 9; in many cases, of course, a good part of the 10.75 dollars will have been omitted from the latter.

As is already evident from Figure 9, only a very few journals employ full-time scientists or engineers as editors. Usually the editors are staff members at a university or other institution, who devote part time to the journal, and in only about half the cases do they receive some sort of stipend from the journal. Thus, in a subset of 36 journals with part-time editors—mostly from our Sample (2)—24 paid a stipend to the editors in 1968, 12 did not. In the 1962 data of Campbell and Edmisten[7], 48 percent of all journals paid such a stipend, the percentage being rather higher for university-press

journals and lower for commercial ones. There were also interesting variations from field to field, the percentage receiving remuneration being only seven percent in mathematics, but 70 percent or more in physics, chemistry, and engineering. For those journals of our sample (most of the 36) for which data were available, the average compensation to the editors was around 3,000 dollars per published megaword; this is less than half the unloaded-salary value of the time corresponding to the + point in Figure 10.

Refereeing. Referees usually donate their services, though some journals of private publishers give them an honorarium. As journal offices have no records of the time spent by referees, it is hard to make a dollar estimate of the cost of the refereeing operation to society. Our estimate, based on conversations with a number of typical scientists in various fields, is that the amount of refereeing time per paper refereed is of the same order as the amount of editorial time per paper published. Large high-prestige journals are likely to submit all papers to referees, and in such cases refereeing contributes to true costs almost as much as technical editing. More specialized journals may have much of the evaluation of papers done by the editors, so that less refereeing is needed.

Copy editing and the like. Easier to pinpoint is the cost of copy editing and related expenses, that is, the preparation of manuscripts for the typesetter or other compositor. Copy editors and others involved in this work need to have a variety of special skills, but unlike those who do technical editing they do not need a deep understanding of the technical field of the papers. As was briefly indicated in Figure 8, the

operations to be performed include: marking manuscripts for the typesetter; standardizing headings, footnote arrangements, and the like; planning the layout of figures and tables; and some proofreading. Usually most or all of this is done at the journal production office, but some operations may sometimes be done at the technical editor's office and others may sometimes be done by the printer. In a recent study by Biesel of the American Institute of Physics, the 1967 cost (including overhead) of these "editorial mechanics" operations for a number of journals published by scientific and engineering societies and university-press organizations was found to range from about 7.50 dollars per 1000 equivalent words to over 28 dollars, with most organizations lying in the range of 12 to 16 dollars. The variations seemed to be due partly to variations in efficiency (e.g., a large-scale operation can maintain a more uniform work load than a small one and can employ personnel with higher specialization), partly to variations in the difficulty of the material being processed (we have been told by a multidisciplinary publisher that variations in amount of mathematics, amount from non-English-speaking authors, and the like, can affect copy-editing costs by as much as a factor three), and partly to assumption of a greater or smaller number of tasks by the editorial mechanics group (e.g., provision of assistance to the technical editors in dealing with referees, or turning over the dummying of pages to the printer).

It is worth mentioning that material destined for typewriter composition and photo-offset may require more meticulous copy marking than that destined for monotype composition, because the compositors

may be more sketchily trained. This may negate a small part of the saving in composition costs that we discuss below.

Composition. The great majority of the journals of our Samples (1) and (2) were set in type. In Sample (2), a fraction of the journals of the American Institute of Physics and a fraction of those of the Institute of Electrical and Electronics Engineers were photo-offset from copy prepared on special typewriters in the offices of the journal. A number of other journals were either planning to change to this type of composition or were seriously studying it. Costs of composition are not only different for these two procedures, but vary with the difficulty of the material being set, and from printer to printer, typesetting done in Europe or the Far East being typically less expensive than that done by domestic organizations. In comparing composition costs for different methods of composition it is convenient to lump together the costs of composition itself, of corrections made to proof, and of engravings, since, when typewriter and photo-offset are used, the corrections are much less expensive than for typeset material and separate engravings are not needed. For a number of journals queried, the sum of these three items for composition in 1968 by domestic typesetters usually was in the range of 30 to 40 dollars per thousand equivalent words, depending noticeably on the amount of mathematics and special symbols involved; we were given an estimate that pure text with no symbolic material might be as low as 20 dollars, and 100 percent mathematics without text (a case never realized, of course) as high as 60 dollars. Some European typesetters seem to charge as little as two thirds the domestic rate, even after allowing for additional mailing expenses; those in the Far East

are said to be cheaper still. According to a comparison of Section 1 with the other sections of the Physical Review, typewriter and photo-offset composition seems to be only about two thirds as expensive as domestic typesetting (again for the sum of composition, corrections, and figures, now done by paste-in rather than engravings).

5. Runoff Costs

Figure 11 shows the distribution of runoff costs per 1000 equivalent words per copy produced for those journals of Sample (2) for which figures could be obtained. The data are presented in the form of a graph of specific runoff cost versus the size of an average issue of the journal, since the various items in the runoff cost (see Figure 8) can be grouped into: (a) printing, paper, and postage, nearly proportional to the amount of material printed (copies times pages per copy); (b) covers, wrapping, and mailing, nearly proportional to the number of issues mailed; and (c) maintenance of records and other information on subscribers, nearly proportional to the number of subscribers and independent of the bulk of the journal. As will be seen from the Figure, the great majority of the points lie within ± 20 percent of the arbitrarily drawn full curve. This is not surprising, as item (a) is expected to be fairly uniform for domestic printers. However, the curve is not a simple hyperbola, as the above considerations would seem to suggest; it seems that presswork accounts for something like 80 percent of the runoff costs for journals at the right-hand end of the curve, and for over half at the left-hand end.

Much of the scatter in Figure 11 is due to the fact that different journals adopt considerably different ratios of total run to number of subscribers, that is, save different fractions of the total run

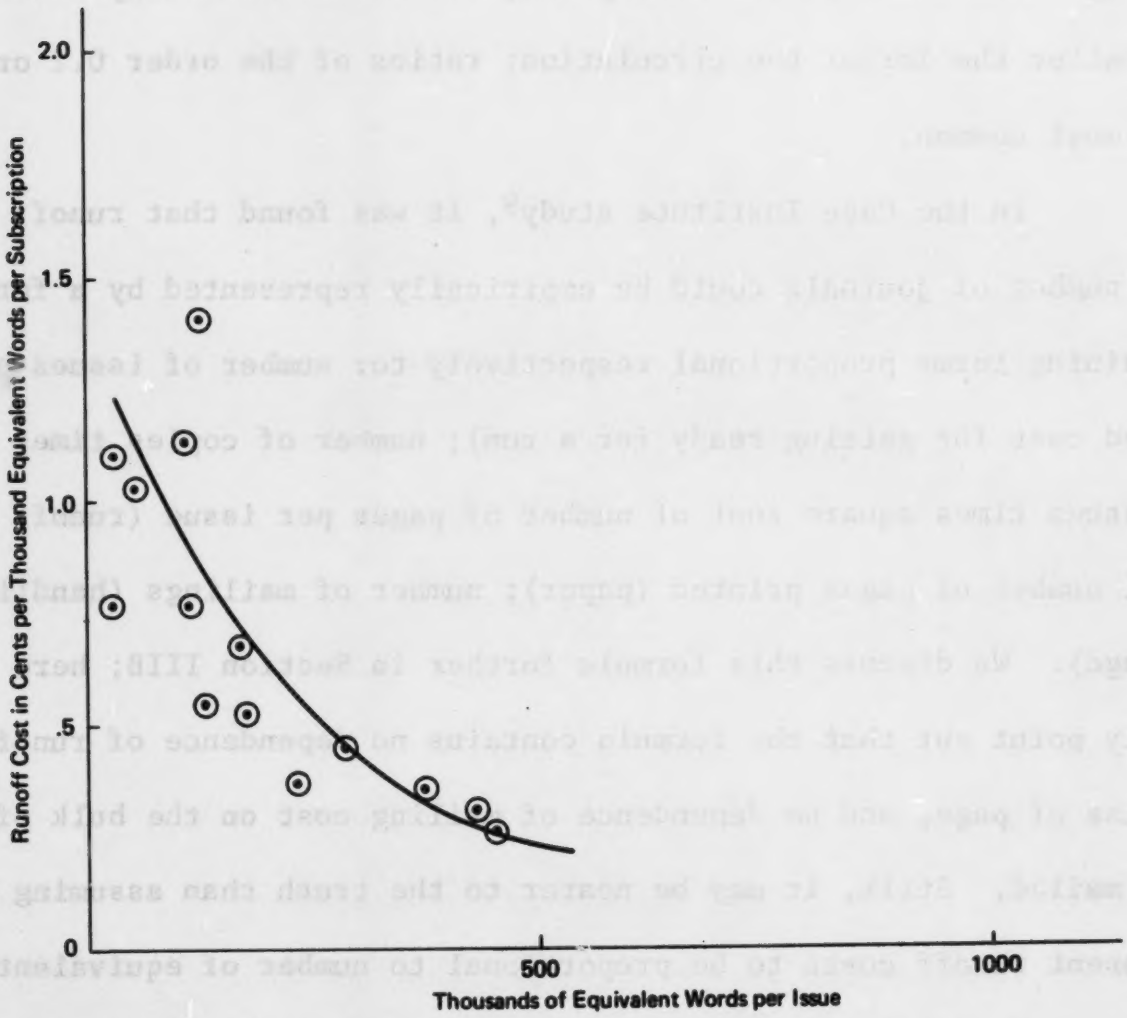


FIGURE 11 Runoff cost (as defined in Figure 8) per unit amount of material printed versus average size of a single issue, for journals of Sample (2) in all fields. The solid curve is an arbitrary one drawn for reference.

for their back-number stocks. Figure 11 was plotted in terms of the quotient of total runoff cost per kiloword by number of subscriptions; it would have been better to plot runoff cost per kiloword per copy produced, but the data were not as often available. Of the data available to us, we observed the ratio of overrun to actual circulation to range from about .05 to nearly 1.7, the values naturally tending to be smaller the larger the circulation; ratios of the order 0.2 or 0.3 were most common.

In the Case Institute study[9], it was found that runoff costs of a number of journals could be empirically represented by a formula containing terms proportional respectively to: number of issues per year (fixed cost for getting ready for a run); number of copies times number of issues times square root of number of pages per issue (runoff proper); total number of pages printed (paper); number of mailings (handling and postage). We discuss this formula further in Section IIIB; here we merely point out that the formula contains no dependence of runoff costs on size of page, and no dependence of mailing cost on the bulk of the item mailed. Still, it may be nearer to the truth than assuming all component runoff costs to be proportional to number of equivalent words.

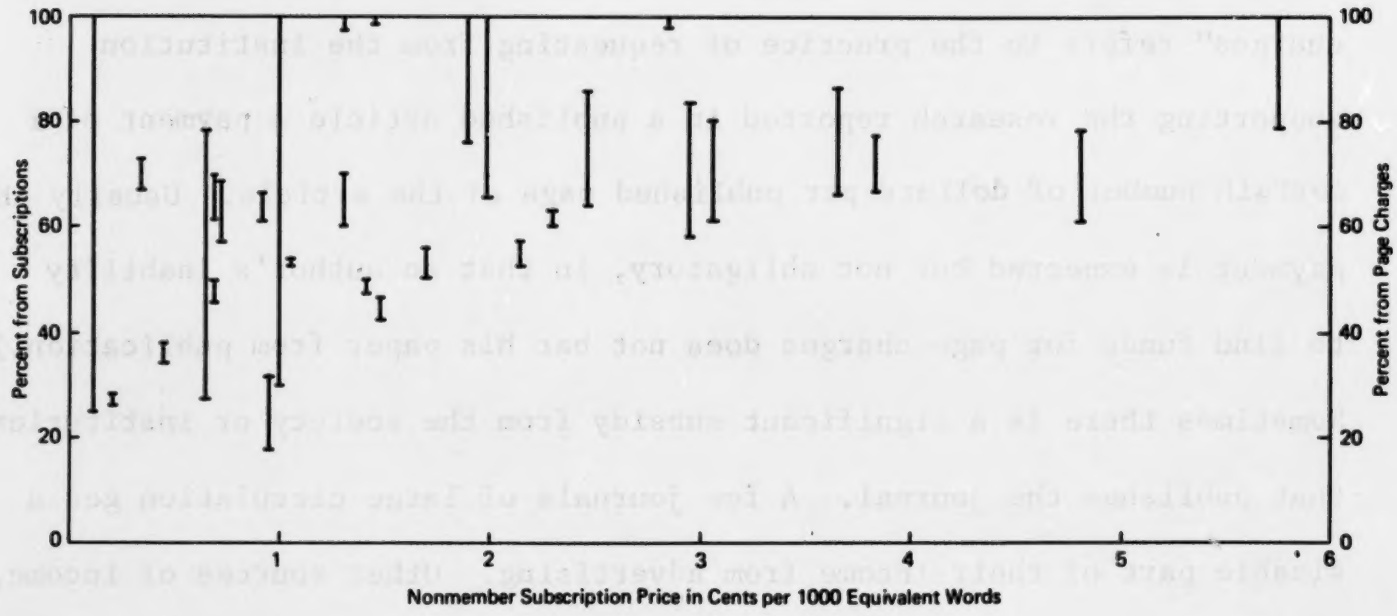
It should be noted that typewriter composition, mentioned in Subsection 4 above as yielding a considerable saving in prerun costs, adds slightly to runoff costs through using more paper.

Closely related to runoff costs, although of course not appearing on the books of journals, are the expenses incurred by libraries to store journals and make them available. These will be discussed in Section IIID.4.

6. Page Charges and Other Sources of Income

Most journals get the great bulk of their income from subscriptions and, in many cases, from page charges. (The term "page charges" refers to the practice of requesting from the institution supporting the research reported in a published article a payment of a certain number of dollars per published page of the article. Usually the payment is expected but not obligatory, in that an author's inability to find funds for page charges does not bar his paper from publication.) Sometimes there is a significant subsidy from the society or institution that publishes the journal. A few journals of large circulation get a sizable part of their income from advertising. Other sources of income, equally minor, include royalties, endowments, and sales of reprints and back numbers. Details of the distribution of these sources of income, as of 1962, can be found in the Campbell and Edmisten report[7].

All the data we have been able to gather on income statistics have been for journals of Sample (2) published by U.S. scientific and technical societies. For each of these journals, the fraction of its 1968 cash income received from subscriptions is plotted up from the bottom of both the graphs in Figure 12, and the fraction received from page charges is plotted down from the top. The two points for a given journal are connected by a vertical line, the length of which thus represents the fraction of the total income received from sources other than these two (e.g., reprints and back numbers, advertising, society subsidy if explicitly listed as an income item). Note that income need not balance costs for a particular journal for a particular year, though most societies try to maintain a general balance for their journals.



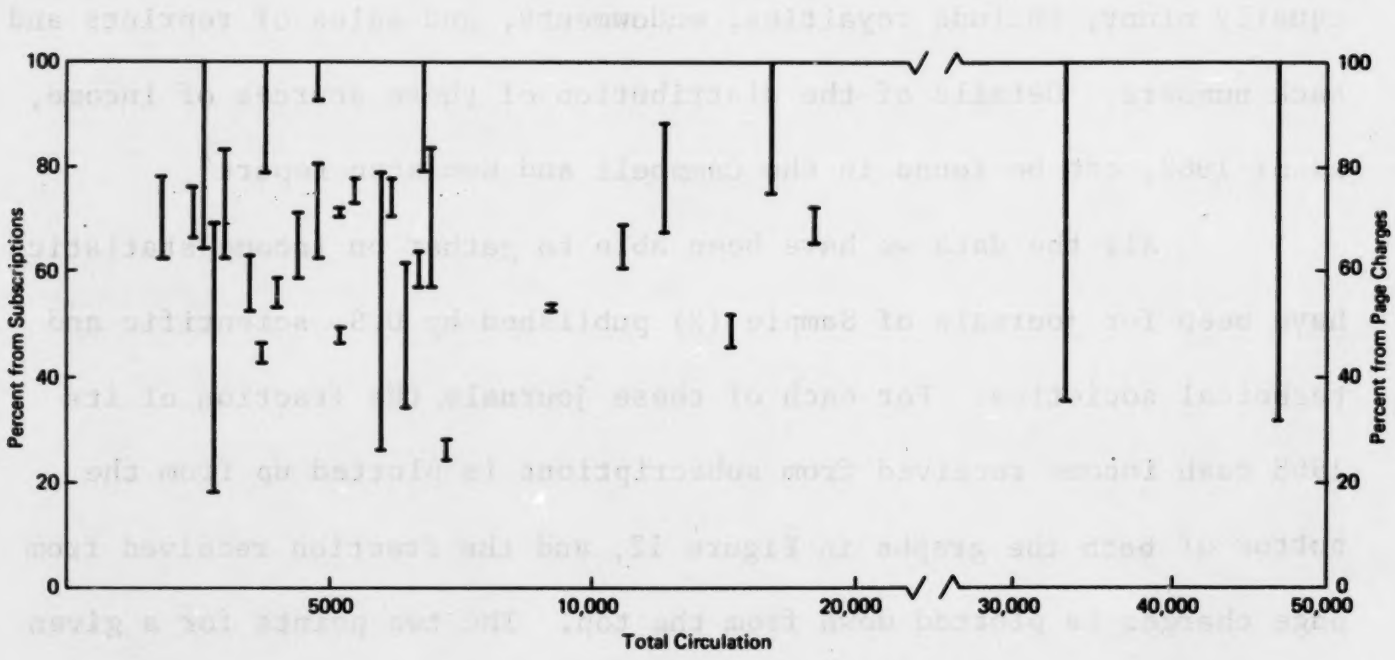
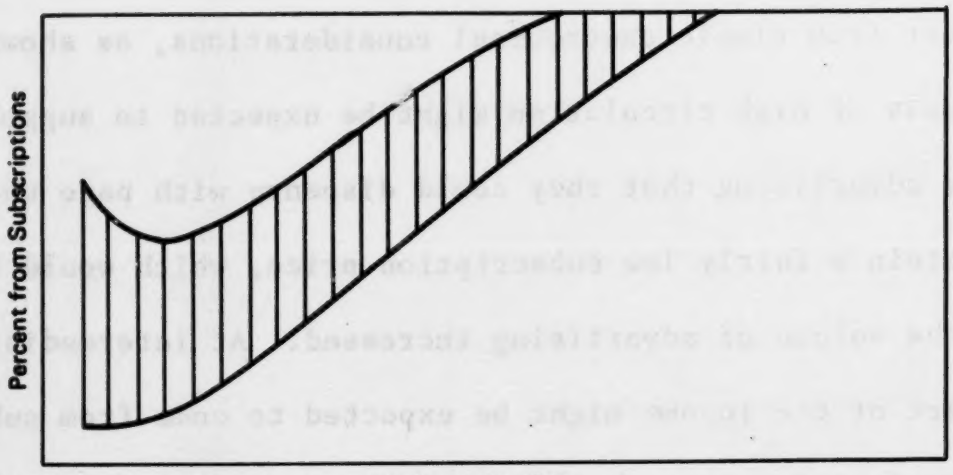


FIGURE 12 Percentages of total income appearing on the books of journals of Sample (2) derived from subscriptions (distance from bottom of graph to lower edge of vertical mark), from page charges (distance from top of graph to upper edge of vertical mark), and from other sources (length of vertical mark), as correlated with subscription price (upper graph) or circulation (lower graph). Here "total income" is interpreted as the gross income from subscriptions and page charges plus the net income from advertising, reprints, back numbers, etc.

The two graphs in Figure 12 have as abscissas two of the variables most likely to be correlated with these percentages, namely, the total circulation and the price per thousand equivalent words, respectively. It should be borne in mind that our sample is representative mainly of the larger society journals, though a few smaller ones have been included.

It is interesting to compare Figure 12 with the behavior one might expect from simple theoretical considerations, as shown in Figure 13. Journals of high circulation might be expected to support themselves so well by advertising that they could dispense with page charges and still maintain a fairly low subscription price, which would become rapidly lower as the volume of advertising increased. At intermediate circulations, a major part of the income might be expected to come from subscriptions. At low circulations, page charges might be expected to constitute the largest item of income, but at very low circulations they might need increasing assistance from general society funds—hence, the pattern shown in the bottom diagram of Figure 13. Similar considerations suggest the pattern of the top diagram. Subscription income decreases with decreasing price in the range covered by these journals (see the discussion and relevant figure in Section IVA.1). Journals of high price can function without page charges or subsidies if they are willing to accept small circulation; the latter forms of support become increasingly necessary as the price is lowered. Large-circulation journals with much advertising, however, can offer the lowest prices of all and do not need page charges. Real journals, with their diversity of circumstances, can be expected to show wide fluctuations around these patterns. Indeed, the resemblance of Figure 12 to the ideal pictures of Figure 13 is rather poor, though some of the features are perceptible.



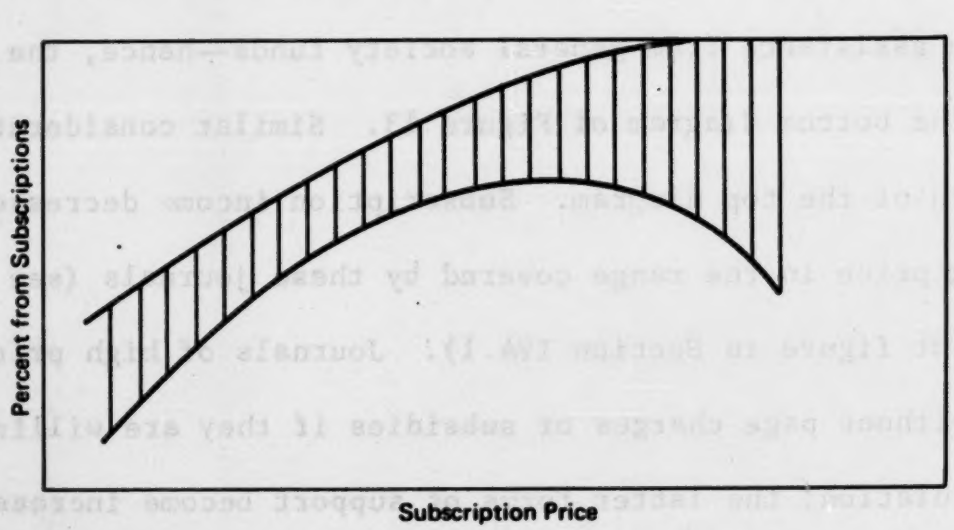


FIGURE 13 A guess at a plausible theoretical behavior for the distribution of sources of income. (Graphs have the same meaning as in Figure 12.)

Page charges. Let us now take a more detailed look at page charges. The first question one might ask is: How widespread is the practice of imposing page charges? This question has been the subject of several other studies, both in prior years[7,8,15,16] and recently[14,15,17,18,19]. Here we discuss the 1968 situation only, deferring until Section IIIB the discussion of trends with time. Figure 14 shows the distribution of U.S. society and nonprofit journals in various scientific and technical fields included in our Samples (1) and (2) with respect to imposition or nonimposition of page charges. For two of the fields (mathematics and biology), more careful 1968 studies[14,15] are available and their results are shown in solid bars. It is evident from the Figure that the page-charge practice has in recent years spread from its place of origin in the American Institute of Physics into all scientific and technical fields and that, although it may still be used a little more in physics and chemistry and a little less in engineering, its prevalence no longer varies by a large factor from field to field. The practice now seems to be followed by the majority of journals published by scientific and technical societies and by other nonprofit groups in the United States. On the other hand, a very few (six percent or so) of the journals of private (for-profit, commercial) publishers in our sample impose page charges, and only a very few of the foreign society and nonprofit journals do so. (See Figure 15.)

The magnitude of the page charges varies widely, as shown in the histogram of Figure 15. Part of the spread is due to variations in page size; a journal with a large page is likely to impose a higher charge than one with a small page. But much of the spread is real and

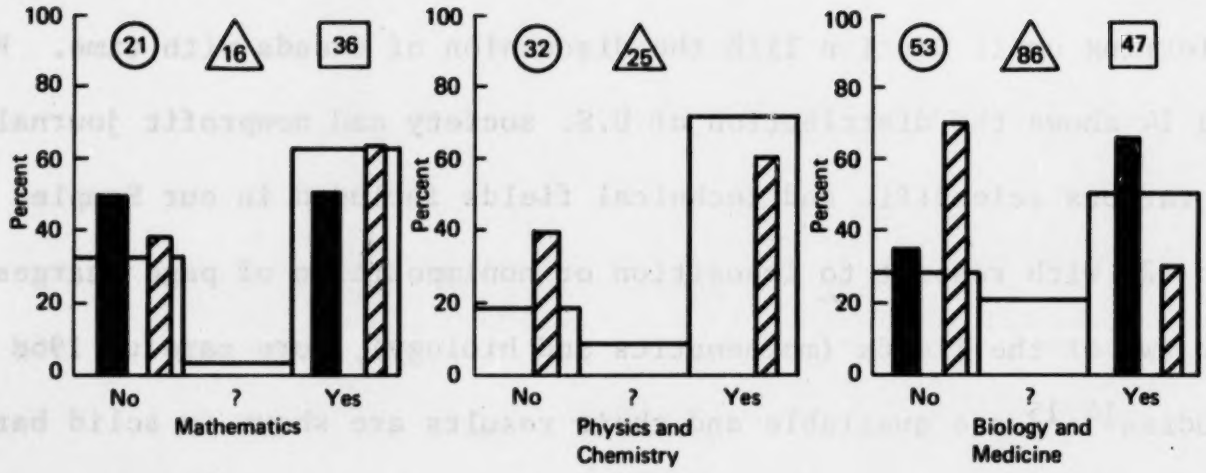
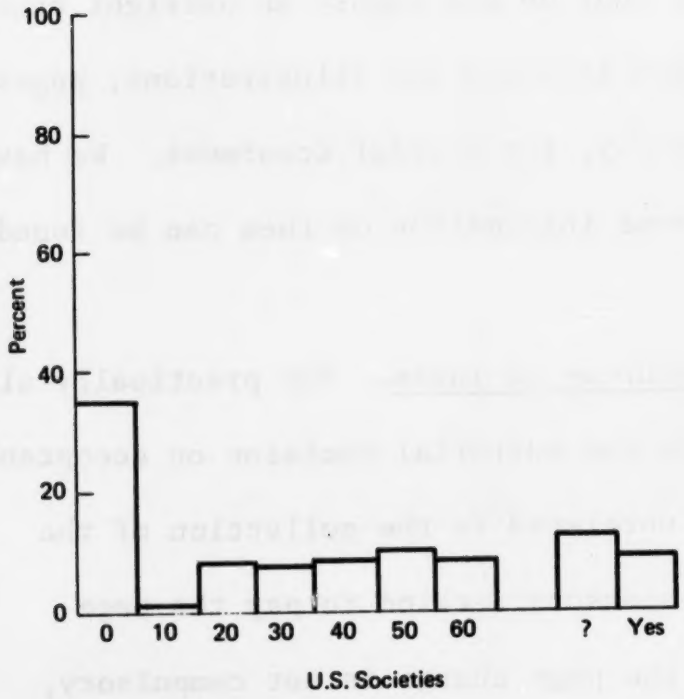
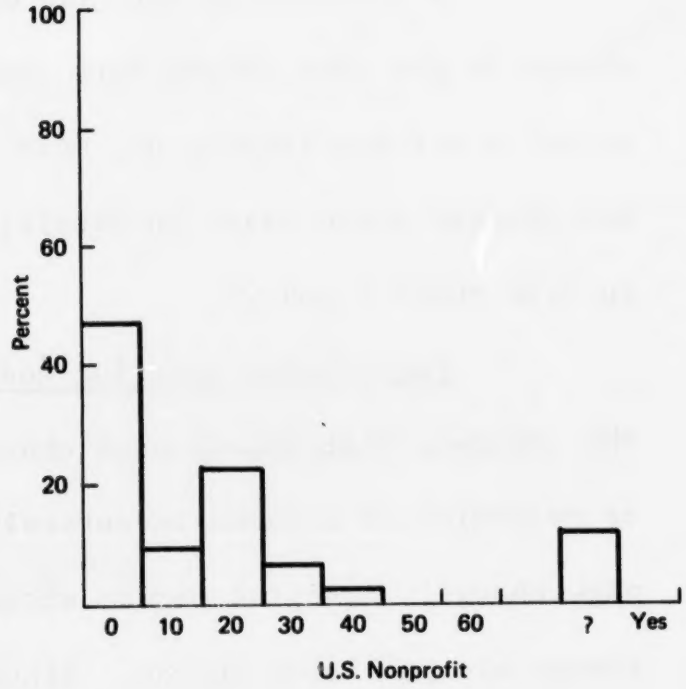
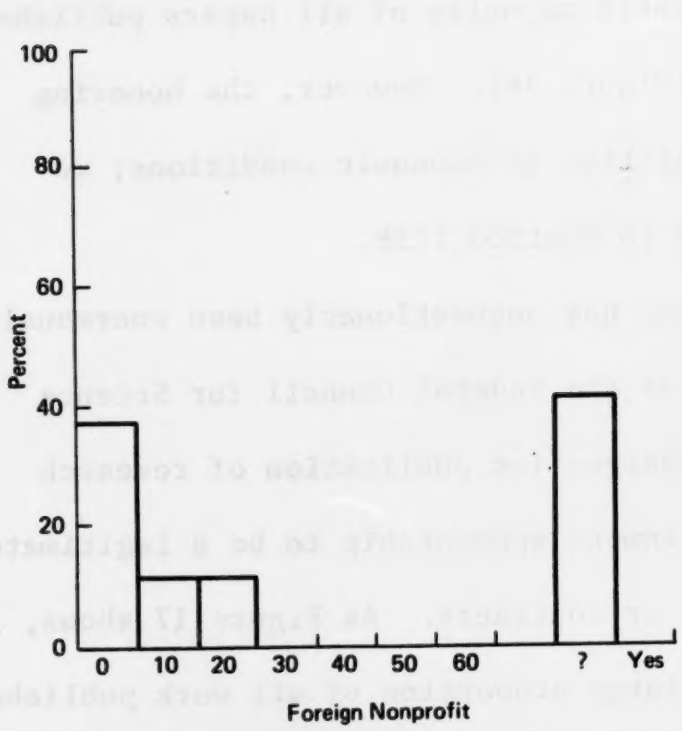


FIGURE 14 Distribution of journals of U.S. societies and nonprofit groups with respect to imposition of page charges in 1968. The wide bars are for journals of Samples (1) and (2), as described at the start of Section III; the number of journals in each portion of the sample is circled. As the information was in many cases obtained from inspection of the inside covers of the journals, a category of questionable cases (no clear information obtained) is placed between "no" and "yes"; presumably most, but not all, of these would be "no." The narrow black bars represent the results of 1968 studies on slightly larger samples (numbers in squares) by the American Mathematical Society[14] and the Council of Biology Editors.[15] The narrow diagonally shaded bars represent 1966 statistics of the Engineers Joint Council[16] (number in square) and of the George Washington University study[17] (numbers in triangles).







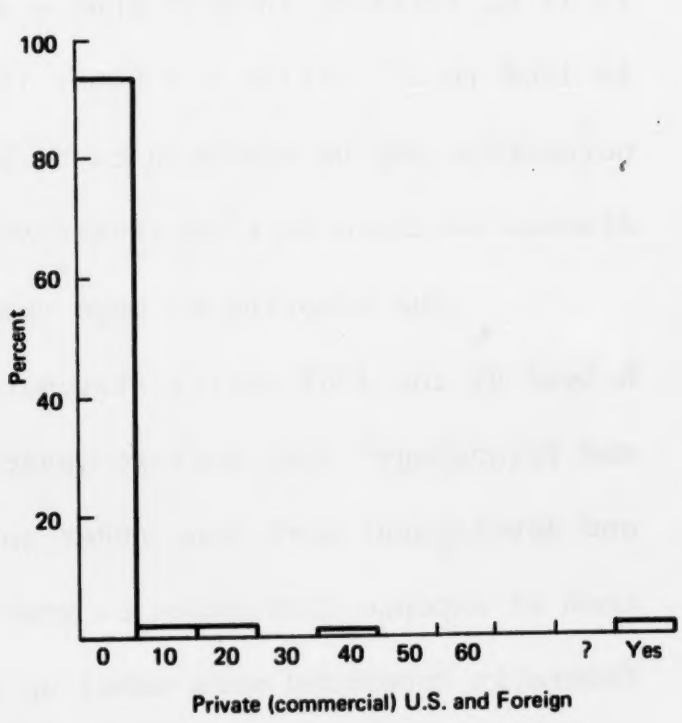


FIGURE 15 Percentages of journals of various types of publishers whose page charges are zero or in various ranges above $ (N–10) and below or equal to $N, where N is the number at the bottom. Data are from our Samples (1), (2), and (3). As in Figure 14, journals for which we were not able to establish with certainty the existence or nonexistence of a page charge are plotted above a question mark; those for which there was known to be a page charge but its magnitude was not known are plotted above the word "yes."

reflects the fact that many journals have adopted page charges reluctantly and wish to keep them as small as possible.

A fraction of the journals that do not impose an outright page charge do get some income from charges assessed for illustrations, pages beyond a certain length, or, more rarely, for special treatment. We have not studied these cases in detail; some information on them can be found in References 7 and 17.

Page-charge honoring and sources of funds. For practically all the journals that impose page charges, the editorial decision on acceptance or rejection of a paper is entirely unrelated to the collection of the page charge. Accepted papers whose sponsors decline to pay the page charge are published anyway. Since the page charge is not compulsory, it is of interest to note that a sizable majority of all papers published in 1968 in all fields did honor it (Figure 16). However, the honoring percentage may be expected to be sensitive to economic conditions; we discuss evidence on this sensitivity in Section IIIB.

The honoring of page charges has unquestionably been enormously helped by the 1961 policy statement of the Federal Council for Science and Technology[5] that declared page charges for publication of research and development work done under government sponsorship to be a legitimate item of expense chargeable to grants or contracts. As Figure 17 shows, federally sponsored work makes up a large proportion of all work published in U.S. journals in all fields of science and technology, often well over half. The availability of money to pay page charges for this work is attested both by the experience of typical journals and by the fact that—at least for projects sponsored by the National Science Foundation and the Atomic Energy Commission—the overwhelming majority of

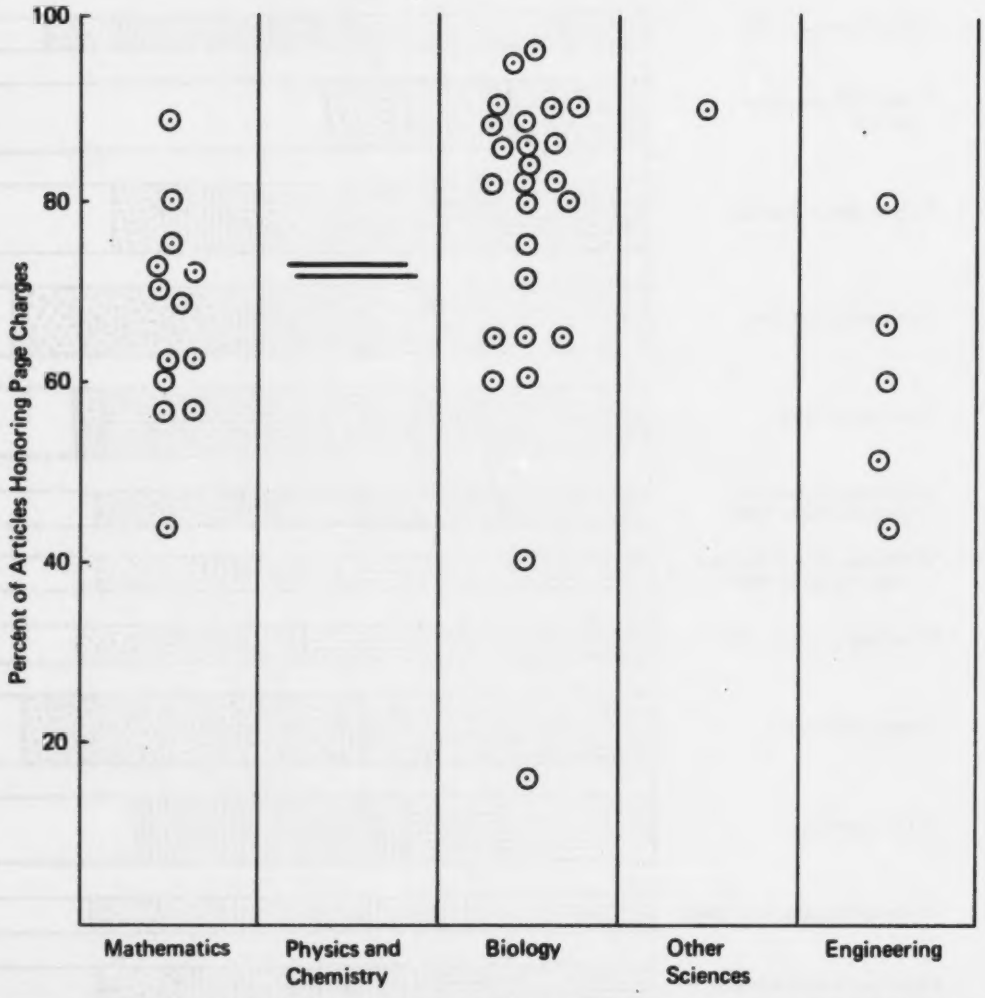


FIGURE 16 Scatter diagrams indicating the percentage of articles for which page charges were honored in samples of journals in major fields included in Sample (2). The two horizontal lines in the Physics and Chemistry column represent coverages for many journals published by the American Institute of Physics and the American Chemical Society.

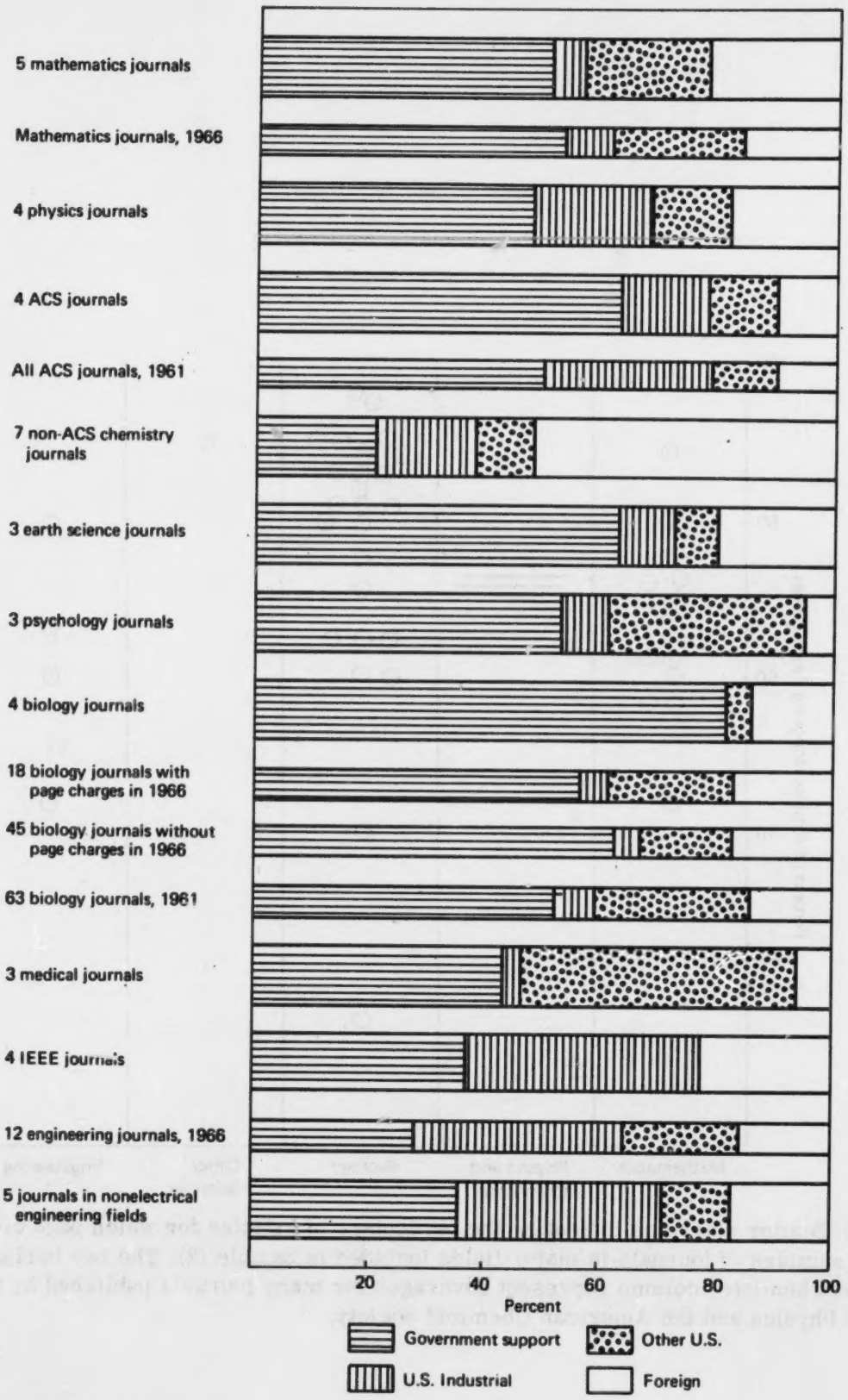


FIGURE 17 Sources of support for work reported in various samples of U.S. journals. The present 1968 data, shown in wide rows, are from rather small samples, so are subject to sizable uncertainties. For these data the category "U.S. government or government sponsored" includes all work done in government laboratories and all work done under government contracts or grants. The narrow rows show data from other studies in prior years, and give some idea of the slow upward drift, with time, of the proportion of work receiving government support. The 1961 ACS data are from an American Chemical Society study,[24] augmented by our arbitrary assumption that 10% of the 1961 papers were foreign; the other 1961 and 1966 data are from the GWU Report.[17]

research grants and contracts do at present contain a budget item of reasonable size for publication. The Figure also shows the amounts of work supported by U.S. industries or done in foreign countries. Though the distribution of papers not honoring page charges varies somewhat from journal to journal, these papers typically consist of most of the foreign ones, a sizable portion of the "other U.S." category, and only a few from the government and industrial categories. The George Washington University study[17] supplies many additional details; see also Reference 24. In regard to industrial work, it is noteworthy that in the George Washington University study[17], page charges were honored by all of the 49 industrially supported papers on which such charges were assessed; however, some engineering journals we have queried report much less favorable statistics. The success of the page-charge system thus rests on the smallness of the "foreign" and "other U.S." categories.

Advertising. Besides subscription and page-charge income, shown respectively below and above the vertical line segments in Figure 12, there are a variety of contributions to the lengths of these segments. One of these is advertising income. Many journals carry some advertising—for example, 47 percent of those in the George Washington University study[17] were found to do so, and about 52 percent of those in the Campbell and Edmisten study[7]. But only rarely does the net income from advertising support a sizable part of the cost of publishing research material. Figures on gross income from advertising are more often tabulated, but are less useful as an indication of the benefit a journal receives through advertising. In the Campbell and Edmisten study[7], no university-press journals and only about one tenth of all society journals were found to

receive more than ten percent of their income from advertising, and even this figure may represent gross rather than net income. For commercial journals the figure was about one fifth. Our own study, though based on a smaller sample, confirms this picture and reveals a little about the correlation with circulation.

We obtained data of two sorts. One consisted of figures on advertising income and on the cost of producing advertising material for the 20 journals of Sample (2) that carried advertising. The other consisted of counts of pages of advertising material in 16 of these and 19 other journals for which circulations were known to be over 5,000. While there is naturally a strong correlation of advertising income with advertising pages, it is far from perfect. Usually, to get a net advertising income in excess of ten percent of the cost of producing the research part of a journal, the journal must devote five or ten percent of its pages to advertising, but there are exceptions. In our sample, only four of 21 journals in the 5,000-10,000 circulation range devoted more than five percent of their space to advertising, and only two of ten in the 10,000-20,000 range. But of the four journals with circulations over 20,000, the number of advertising pages for three was nearly as large as the number of research pages; such journals can well get a net yield from advertising sufficient to cover half to three fourths of the cost of publishing their research material. It is noteworthy, incidentally, that news (or mainly news) journals that support themselves almost entirely from advertising, or even make a profit—for example, Physics Today, Journal of the American Medical Association, Chemical and Engineering News, and Scientific Research—

typically have a volume of advertising material about equal to the amount of nonadvertising material.

Society subsidies. It may be worthwhile to mention one or two statistical observations about subsidies from parent societies. One is that for the great majority of about 100 society publications that we inspected, society members could receive the journal at a lower subscription rate than that charged to nonmembers. In only a small minority of these cases, however, was the receipt of the journal an automatic consequence of society membership. These cases were usually those of small societies publishing a single journal. Larger societies are more likely to give their members a choice of subscribing to any, several, or none of a list of journals, and to provide all their members automatically only with a news-type journal. However, journals that are not automatically provided to all society members usually do receive some financial support from the sponsoring societies; according to the replies that we received from the societies to whom we wrote, this support may range from a negligible amount to 30 percent or more of the total production cost. Generally, the average subsidy to all journals supported by a society is considerably less than this. Such subsidy, when it occurs, amounts to a tax for support of a journal imposed on those society members who do not receive a personal copy of the journal.

Reprints and back numbers. These usually account for only a small part of the total income, the net income from these operations (excess of receipts over costs) being typically two percent to four percent of the total income, though we have heard of values as high as

ten percent or even, for some biomedical journals, over 20 percent. Back-number sales are rather more lucrative for journals of commercial publishers than for society journals, because the many individual member subscribers to the latter provide a plentiful reservoir of second-hand back numbers.

B. Trends with Time

1. Number and Size of Journals: Mortality, Birth, and Growth

It is obvious to every user of the scientific and technical literature that the number of journals is increasing: The birth rate exceeds the mortality. Let us examine these two items separately, starting with mortality.

One does not expect any journal to live forever. Studies of the several centuries of scientific and technical journal literature throughout the world have yielded estimates of the total number of serial titles rather larger than reasonable estimates of the number of titles in existence today[25,26]. Studies of several populations of scientific and technical journals in the first half of the present century[26] have suggested half-lives of the order of 50 years. In theoretical discussions, one sometimes hears talk of "survival of the fittest"—the idea that journals that are inefficiently produced or of poor quality can be forced out of existence by marketplace economics. How valid is such an idea for the basic scientific and technical journals of our nation today?

The question is easy to answer, since the Campbell and Edmisten report[7] contains a list that includes a majority of the basic journals in which we are interested as they existed in 1962. Of about 200

such journals (the ones not starred in the list in their appendix), all but seven appeared unchanged in Ulrich's Directory[27] for 1967-8; further checking of these seven showed that three had merely changed their names, two had merged with other journals, and two remained unaccounted for. Of these two, one could not even be located in the Union List of Serials for 1961, and none appeared in the available lists of serials[28] discontinued in the intervening years. So the number on the original list that really went out of existence in half a decade was surely no greater than two, probably less; even if the mergers are counted, the upper limit is only four. We conclude that under present conditions, the mortality rate for U.S. journals devoted to primary accounts of new knowledge in science and technology for a nationwide or worldwide readership is very small, probably only a fraction of a percent a year.

If this is true, what is the explanation of the higher mortality figures quoted earlier[25,26]? These figures were for a much broader category of journals, covering the entire world and including regional, semipopular, and other types. Although we have not undertaken a quantitative study of these, we have examined samples of listings of journals that have discontinued publication[28] and have concluded that there is indeed a much higher mortality both for foreign basic primary journals and for domestic regional and semipopular ones.

To get a rough estimate of the birth rate of the type of journals we are considering (defined at the start of Section III), we examined all the U.S. journals in all our samples, about 250 in number (see description of these at the start of Section III and in Attachment B).

These journals were selected in 1968, hence were in existence then; all but 37 of them could be verified as having been in existence in 1962, and 34 of the 37 were verified to have originated since 1962. Journals that merely changed name, or which resulted from subdivison of an older journal, were not included in the 37. Insofar as the sample can be considered representative, these figures imply that the current birth rate of new journals of the type considered here is roughly 2.5 percent a year; as very new journals may have been missed by our sampling procedures, this figure is likely to be a slight underestimate. This birth rate seems to be dominated by the commercial journals, whose birth rate is about eight percent a year, as compared to about 1.4 percent for the nonprofit journals.

The mortality being negligible, the rate of increase in the number of such journals is essentially equal to the birth rate just given. It is interesting to note that our figure, an average for many different fields of science and technology, is a few times that of an independent estimate for the total of all journals with chemical material (most of them not satisfying the criteria for inclusion in the present study)[29]. Again, Price[30] reports a doubling time of about 15 years in the rate of founding of new journals, a rate that has been remarkably constant for centuries; this corresponds to about five percent a year.

Examination of the birth statistics did not reveal any clear differences between the various fields in regard to the annual percentage increase in number of journals. The most conspicuous feature was that fewer new journals appeared among the biological journals of our sample

than among those of most of the other fields; however, as most of our biological journals were obtained from lists compiled by others, one might expect new journals to be less likely to be included in our listings for this field than in those for other fields.

It is natural to ask whether the proliferation of journals occurs at about the same rate for large as for small journals, or whether it represents a tendency for large journals to be replaced by smaller ones rather than to grow indefinitely in size. Although we have no definitive statistics on this question, two facts are worth pointing our. One is that some of the largest journals have been growing for a long time at a rate even greater than the total growth of their respective fields (e.g., Physical Review from 1.97 megawords in 1937 to 22.0 in 1968, or Journal of Chemical Physics from 0.82 to 10.4). The other is that the minimum number of journals one would have to scan to see about half or three fourths of the papers in a field has been increasing only slowly: For example, in 1937 about a dozen journals contributed half the papers in Physics Abstracts; the corresponding number for 1965 is approximately 23^{31}.

Despite the continual appearance of new journals, it is well known that existing journals—and not only the few largest—are getting bigger. Figure 18 shows, for about 50 typical journals, the fractional change in bulk between 1968 and some earlier year. The points in the figure include all the journals of Sample (2) for which the publishers supplied data on bulk, and a roughly random subsample of other journals from Sample (1). No journal is represented by more than one point. The data show that nearly all journals have been growing in size, the median

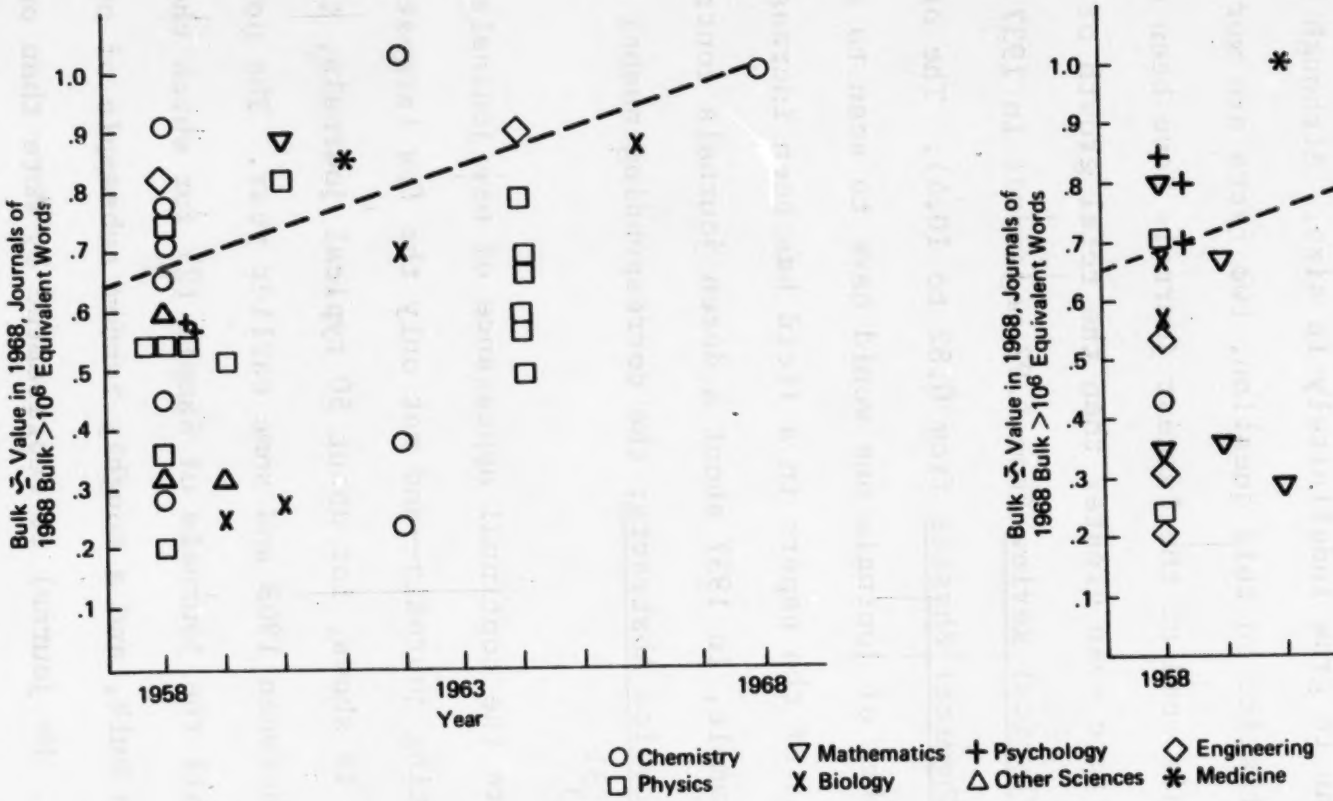


FIGURE 18 Changes in amount of material published by various journals, 1958–1968. Each journal is represented by only one point, whose shape identifies the field of the journal and whose ordinate gives the ratio of its bulk in some one previous year to that in 1968. Large journals are at the left, small ones at the right. The dashed line shows the estimated average rate of growth of U.S. manpower in science and technology (a little over 4% a year).

rate being about a factor of two in a decade (about seven percent a year), with most individual rates lying between twice this and zero. This growth rate seems to be shared by large and small journals alike. There are undoubtedly differences in growth rate from one field to another, but our sample is too small to reveal them clearly. One might be tempted to assume that the overall growth of the literature of a field, though different for different fields, is divided in about the same manner for all fields between new journals and expansion of old ones. However, our rather sketchy biology data suggest that this may not be the case, and that in this field there may be relatively more growth of old journals and less starting of new ones. Obviously a more thorough study is needed.

As we shall soon be contrasting various trends of journals with and without page charges, it is worth noting here that Figure 18 reveals no systematic difference in growth rate between these two types of journals.

Extrapolations into the future are particularly risky in view of the possible leveling off or even decline in the funding of science and technology. In this connection, it is apparent that the increase in the bulk of publication correlates more nearly with research and development expenditures than with manpower figures. The rough data of Figure 18 suggest a doubling in the volume of published literature in the last decade, and this figure must be augmented, though only slightly, to take into account the birth rate of new journals. Available figures on numbers of scientists in various fields[32], numbers of PhD's[32], or total scientists and engineers in research and development[33], give (extrapolated) increases over the last decade of only 1.46 to 1.66.

Extrapolations of similar data on expenditures for total research and development, basic research, and education[33], with a 20 percent correction for purchasing power of the dollar, give increases in the decade of 1.9, 3.5, and 2.2, respectively.

2. Price and Circulation

It is an almost universal lament that journals are getting more expensive. In terms of library budgets this is certainly true. According to a recent survey[34], U.S. periodicals in all fields (not just science and technology) have increased in price by a factor 1.76 in the interval 1958-1968, and those in chemistry and physics have increased by a factor 2.42. The data for our own samples of scientific and technical journals show a similar figure for the growth in price for a yearly subscription. But it is clear from what has just been said in Subsection 1 that most of this increase is due to the increase in the bulk of the journals. If we publish more, somebody, and in large part the subscriber, must pay for it.

This finding suggests that we should look at the changes in subscription cost per page over the last decade. Figure 19 shows some examples of these changes for the same sample of journals that was used for Figure 18 and, as one would expect, no marked differences among the journals of different fields appear. But there is a distinct difference between journals with and without page charges: Journals imposing page charges in 1968 have on the average become cheaper per page in the last five or ten years, while those without page charges have become more expensive, though at an average rate only about that of the consumer price index.

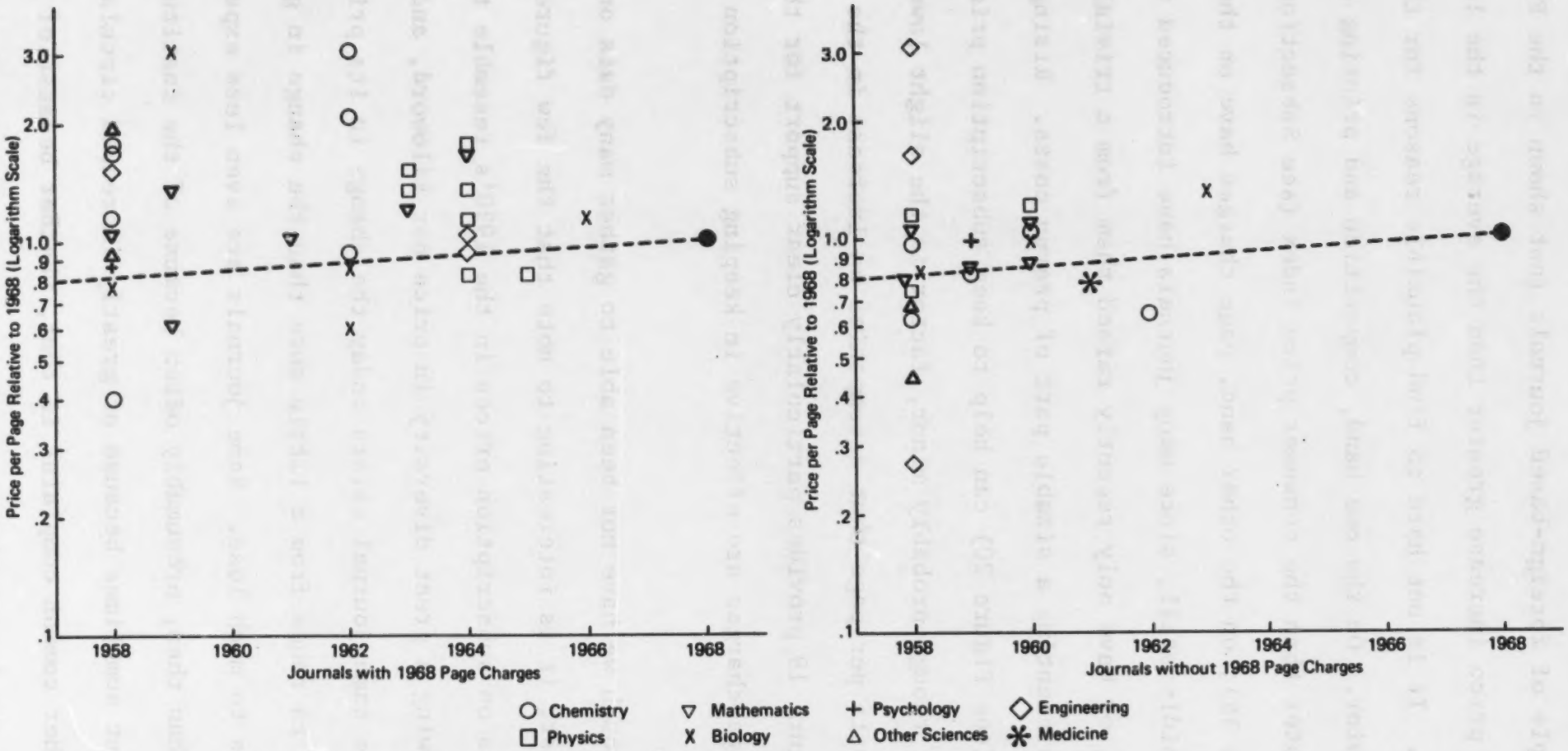


FIGURE 19 Changes in the library price per equivalent word for various U.S. journals, 1958–1968. Each journal is represented by only one point, whose shape identifies the field of the journal and whose ordinate gives the ratio of its bulk in some one previous year to that in 1968. The dashed line gives the average rate of increase of the Consumer Price Index over the decade (1.9% a year).

A limited sample of foreign-based journals (not shown in the Figure) gave rates of price increase greater than the average in the lower part of the Figure. It is not hard to find plausible reasons for these two types of behavior. On the one hand, composition and printing costs have risen faster than the consumer price index (see Subsection 3 below, also Reference 35); on the other hand, page charges have on the average risen more rapidly still, since many journals have introduced them only recently, or have only recently raised them from a trivial level to a level representing a sizable part of prerun costs. Rising circulations (see Figure 20) can help to keep subscription prices down. An additional, though probably minor, factor is the slight lowering of handling costs per page that accompanies an increase in the bulk of an issue. Figure 19 provides particularly clear support for the thesis that page charges are effective in keeping subscription prices down.

Although we have not been able to gather many data on the more remote past, it is interesting to note that the few figures available to us on subscription prices in the 1930's resemble those of 1968 in showing a great diversity in price per kiloword, and that in cases where the same journal exists today the change in its price per kiloword seems to range from a little more than the change in general consumer prices to much less. Some journals are even less expensive per kiloword now than then, presumably often because of the institution of page charges but sometimes because of greatly increased circulation.

Another common complaint is that, whether because of price or bulk, journals are losing their appeal to potential subscribers. While

this has undoubtedly been true in a few cases, our data do not support it as a generalization. Figure 20 shows recent changes in circulation for over two dozen U.S. journals in various fields. As all these journals were published by scientific or technical societies, we can plot separately the number of member subscribers, who often get the journal at a reduced price, and the number of nonmember (mostly library) subscribers. The Figure shows that nonmember subscriptions have been increasing for nearly all of the journals and that for the great majority of them member subscriptions have been increasing also. This latter increase is not due to members being forced to accept the journal, as there were only three journals in this group (identified in the Figure by extra circles) that did not give society members the option of not subscribing. The average rate of growth of circulation seems to be about five percent a year for the nonmember part and a little less for the member part, but still not below the four percent average annual rate of growth of PhD-level personnel[32]. Journals with and without page charges do not seem to differ much in their circulation behavior, and no reliably identifiable differences between different fields are apparent.

In Figure 20 we have omitted data for journals that have subdivided between the dates for which circulation figures were supplied to us. Subdivision is of course expected to decrease the number of subscribers taking the full journal but to increase the number who take at least one of the subdivisions. It may either increase or decrease the number who take a particular one of the subdivisions. Of the journals for which we obtained circulation figures, there were only

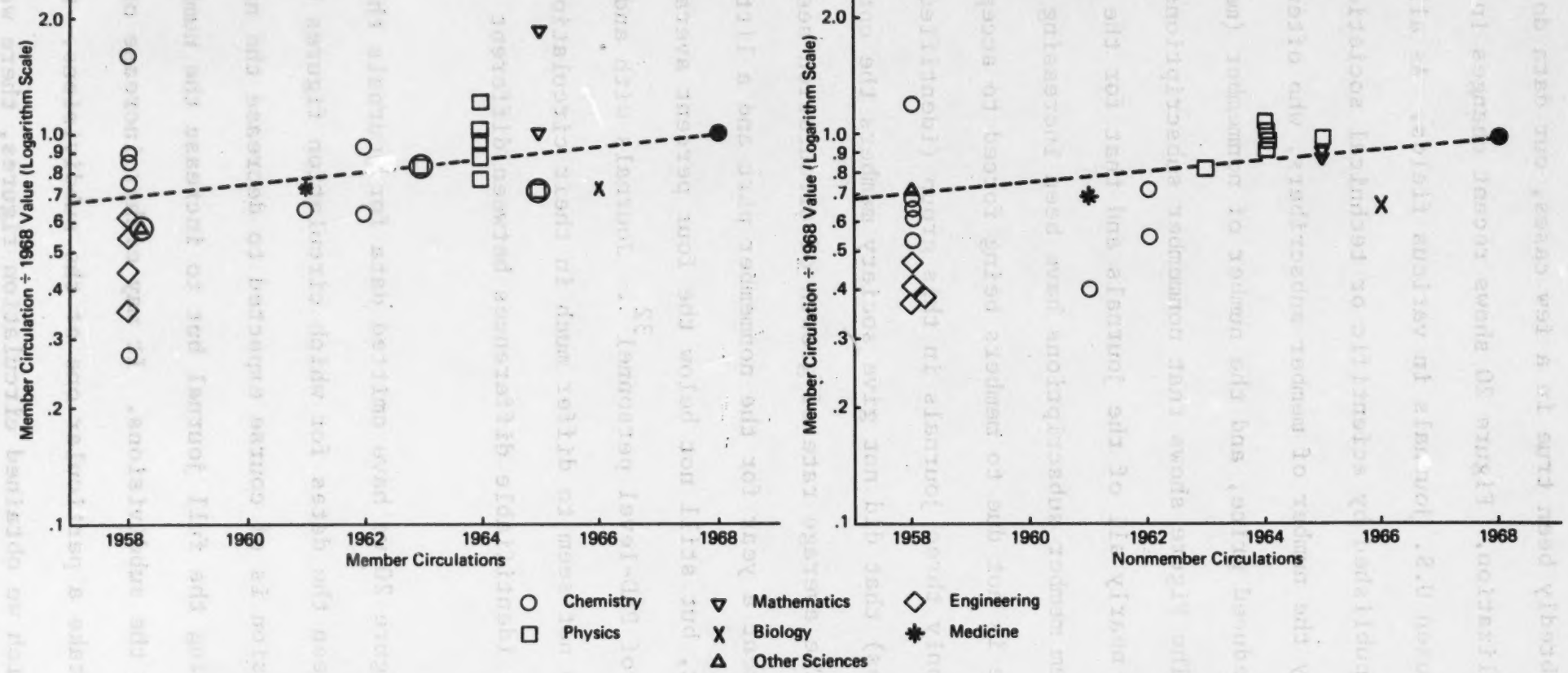


FIGURE 20 Changes in the member and nonmember circulations of a number of U.S. society journals, 1958–1968. Each journal is represented by only one point, whose shape identifies the field of the journal and whose ordinate gives the ratio of the circulation in some one previous year to that in 1968. The dashed lines show the average rate of manpower growth in science and technology (about 4% a year). The symbols inside a larger circle designate journals of societies that sent them automatically to all members.

three or four cases of subdivision in the last decade. (It is sometimes hard to distinguish subdivision from the inauguration of sister journals.) In all cases, the average number of subscribers to any one section after the subdivision was less than the number of subscribers before the subdivision; in one case, however, this could have been predicted from the fact that all society members received the journal automatically before the split, but received only one section afterward. In another case, the publisher considers the split to have been infelicitous, since the numbers both of member and of nonmember subscribers to each section declined in the second year after the split.

3. Cost and Income

We have not collected any very detailed statistics on the variation of production costs over the years. The publishers of the journals of our Sample (2) were asked, among the many other questions, to tell us how costs had been changing, but it would have been unreasonable to ask for as detailed a breakdown of costs for prior years as we wished for 1968, and if such data had been provided its interpretation would have been difficult. However, many of the publishers apparently did have figures of their own on the overall changes in unit costs for composition and printing and for their own office operations. Some merely commented in language such as "the unprecedented rise in printing costs"—implying that unit costs had been rising considerably faster than the average 1.9 percent annual rise in the consumer price index. Others gave estimates of the current rate of increase in unit costs, estimates that varied from below two percent a year to five percent or more, with more of the estimates lying near

the upper figure than near the lower. Kuney[36] has estimated a rise of three percent a year. Koch[37] has quoted an average rise of 3.2 percent per year in prerun costs per page for journals of the American Institute of Physics from 1964 to 1969. Schier[38] has quoted a rise of 3.5 percent per year in the costs of printing and paper. Essentially all of these figures refer to type composition and letterpress printing. As we have noted in Section IIIA.4 above, journals that have shifted to typewriter composition and photo-offset have reduced their composition costs.

Another approach to unit cost increases is to compare data from earlier studies with those of our Section IIIA. This is risky, of course, as the populations are different. The Case Institute[9] formula for runoff cost was:

1959 runoff cost per thousand equivalent words per copy produced

$$= \frac{\$421{,}000}{nIw} + \frac{\$8.15}{I^{\frac{1}{2}}w} + \frac{\$0.78}{w} + \frac{\$7.35}{Iw},$$

where n = number of copies produced, I = pages per issue, w = equivalent words per page (as defined in Section IIIA.1). The four terms correspond respectively to make-ready (really a part of prerun but usually reported with runoff), presswork, paper, and mailing. Although, as we noted in Section IIIA.5, the last term seems to take inadequate account of the increase of postage with weight, it was found empirically that this formula, augmented by a term for composition, fitted the printer's charges for many journals to ±10% or so. Some calculations with this formula for various n and w are shown in Figure 21 as functions of I and compared with various fractions of the empirical 1968 curve of Figure 11. If one allows for a reasonable correlation of page size with issue size, one

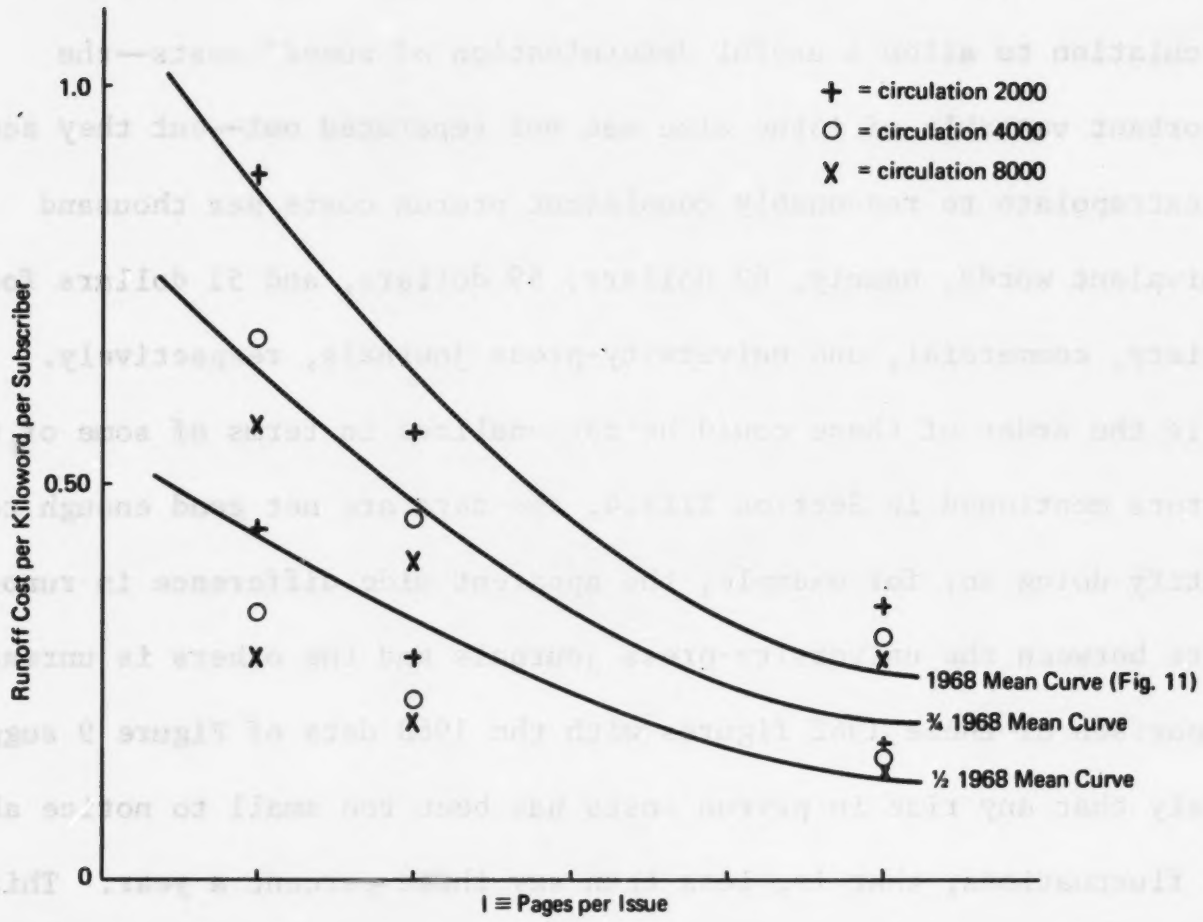


FIGURE 21 Comparison of runoff costs for various hypothetical journals as computed from the Case Institute formula (fitted to 1959 data),[9] with various fractions of the 1968 empirical curve of Figure 11. For each symbol the upper point is for page size 400 words, the lower point for page size 1000 words.

can infer, with considerable uncertainty, that unit runoff costs have increased over the nine years, perhaps by something like 4/3 (three percent a year).

Again, the Campbell and Edmisten study[7] gave some figures on 1962 total production costs for journals of various types, which are plotted in Figure 22. These show too erratic a variation with circulation to allow a useful determination of runoff costs—the important variable of issue size was not separated out—but they seem to extrapolate to reasonably consistent prerun costs per thousand equivalent words, namely, 62 dollars, 59 dollars, and 51 dollars for society, commercial, and university-press journals, respectively. While the order of these could be rationalized in terms of some of the factors mentioned in Section IIIA.4, the data are not good enough to justify doing so; for example, the apparent wide difference in runoff costs between the university-press journals and the others is unreasonable. Comparison of these 1962 figures with the 1968 data of Figure 9 suggests merely that any rise in prerun costs has been too small to notice above the fluctuations, that is, less than say three percent a year. This result may be a little affected by the few journals that have adopted typewriter composition.

The increase in total production costs has been, of course, much more rapid than that in unit costs because of the rapid rise in both bulk and circulation, which we have just noted in Subsections 1 and 2 (Figures 18 and 20). The circulation increases obviously have been a help financially, rather than a hindrance, as journals are hardly ever sold at less than runoff cost. Thus, for example, the total runoff cost

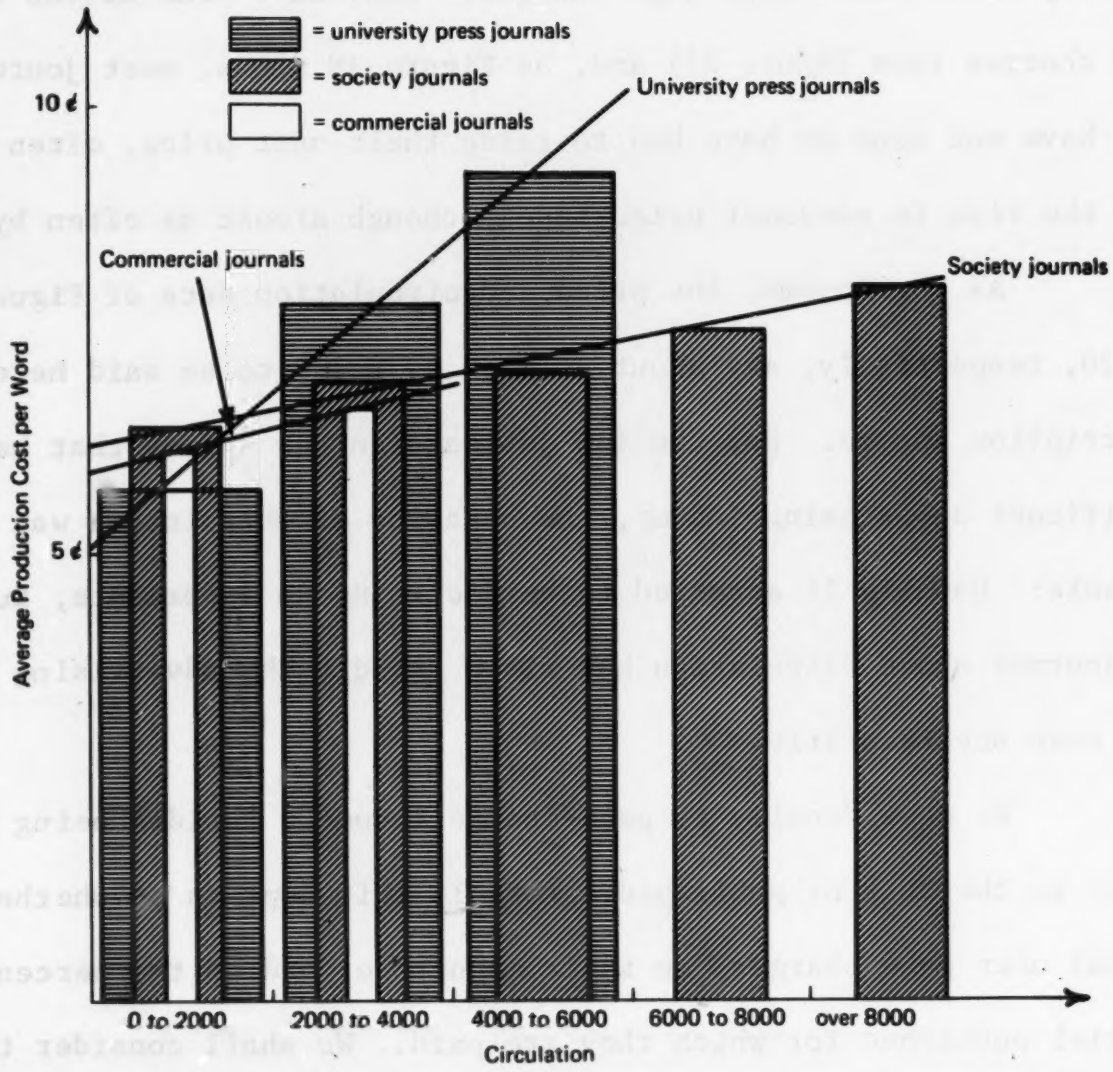


FIGURE 22 Average 1962 total production costs of three types of journals in various ranges of circulation size, as tabulated by Campbell and Edmisten.[7] Lines drawn by eye for extrapolation to approximate prerun costs.

per page for journals of the American Institute of Physics did not increase from 1964 to 1969[37], declining circulations balancing rising unit costs. On the other hand, the increases in bulk have taxed the resources of society journals that have tried to support prerun costs by means other than page charges. Many have been driven to adopt page charges (see Figure 21) and, as Figure 19 shows, most journals that have not done so have had to raise their unit price, often by more than the rise in consumer price index, though almost as often by less.

As for income, the price and circulation data of Figures 19 and 20, respectively, say about as much as needs to be said here about subscription income. For the few journals in our survey that had significant advertising income, the behavior of this income was highly variable: Usually it appeared to be declining in importance, but for one journal whose circulation had risen rapidly the advertising income also rose spectacularly.

We come finally to page-charge income. Besides being proportional to the bulk of published material, this depends on whether the journal uses page charges, on their magnitude, and on the percentage of material published for which they are paid. We shall consider these three items in turn. Figure 23 shows two estimates, both rather rough, of the growth with time in the number of journals with page charges. The growth has been rapid indeed, although it will have to decrease in the near future, as, according to Figure 14, half or more of all journals of the type of interest to us had adopted them by 1968. Figure 24 shows, for a few specific journals, how the size of the page charge has been changing in recent years. It is clear that the average rate of increase

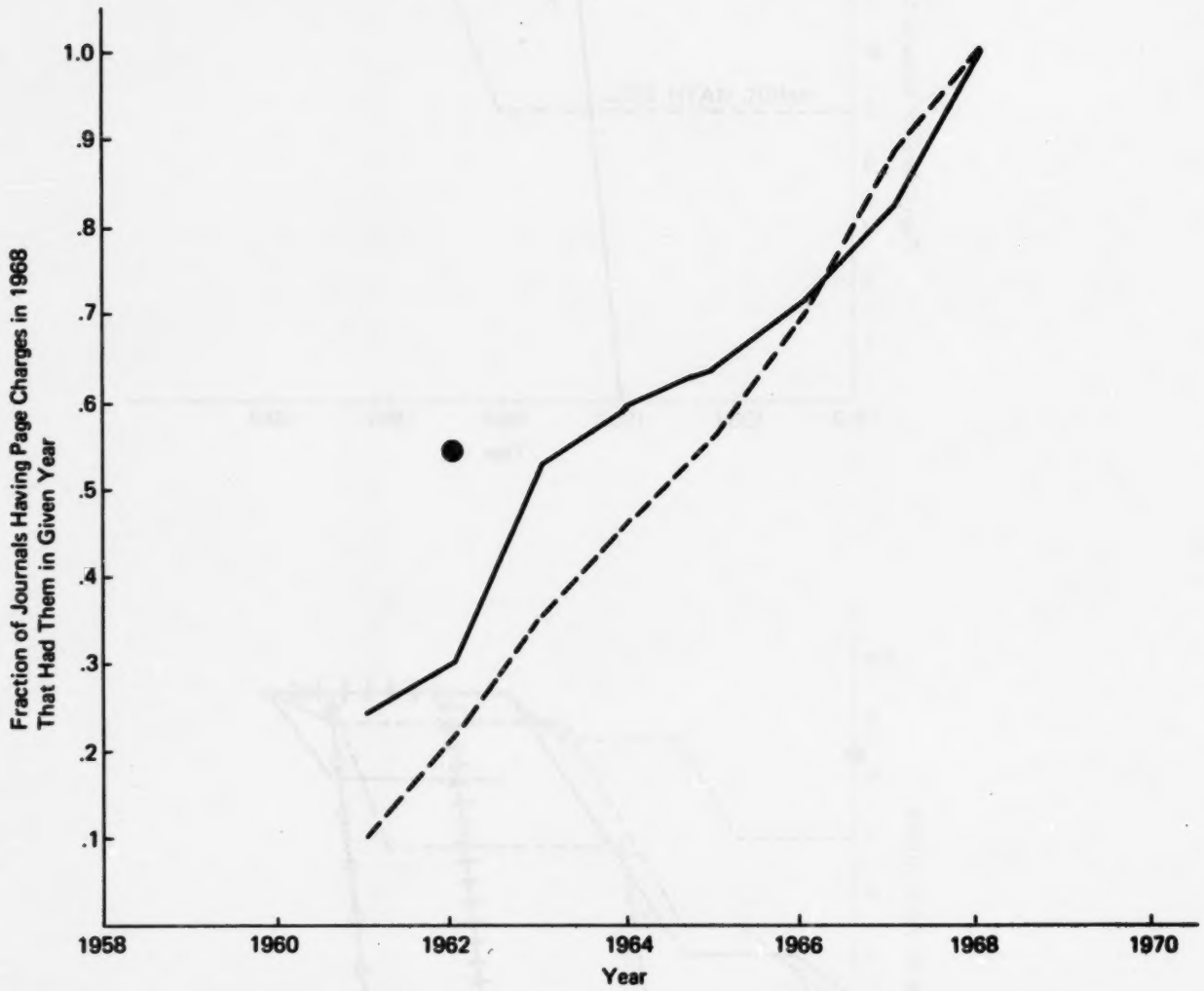
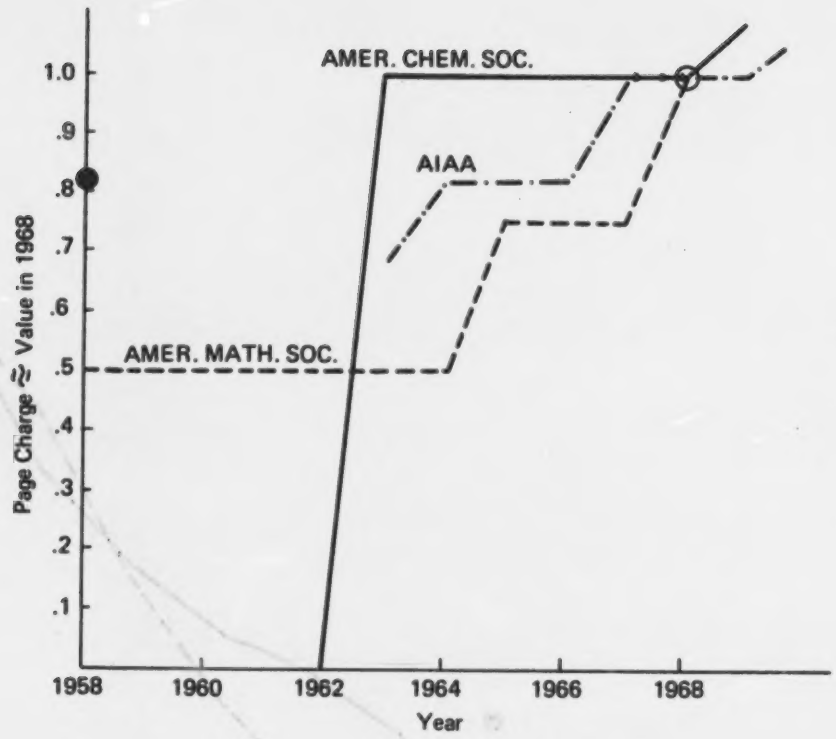


FIGURE 23 Growth of the page-charge practice with time. Full curve = fraction of a sample of 53 society journals, using page charges in 1968, that used them in each prior year back to 1951. Point = estimate of the same fraction for 1962, derived from a comparison of the 1968 sample of Figure 14 with the 1962 sample of Reference 7. Dashed curve = same fraction, for the 1968 sample of biology journals in Reference 15.



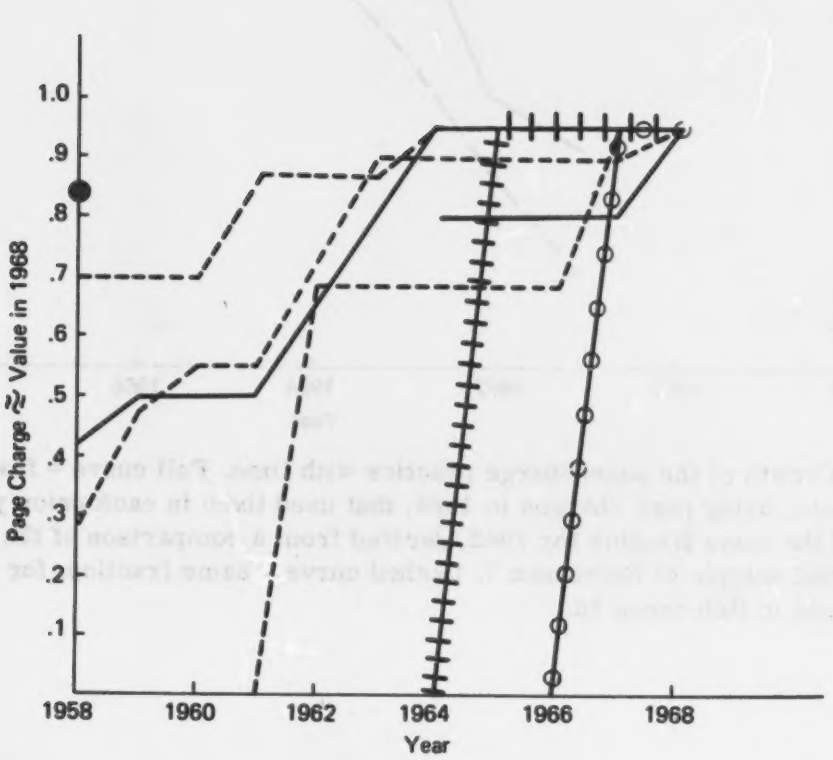


FIGURE 24 Change with time in sizes of page charges: averages for major journals of three societies (top graph); seven individual journals of other societies (lower graph). The dot at 1958 shows the corresponding change in the Consumer Price Index.

in the page charge for most journals in the last five or ten years has been well above the 1.9 percent annual average rate of rise of the consumer price index, and that for many of them it has been greater than the four percent or five percent estimated rise in unit production costs. For most such journals, the percentage of income from page charges has been rising.

The percentage of page charges that are paid, finally, depends on several factors. One is the distribution of sponsorship of the published papers between government contracts, industry, foreign institutions, and domestic institutions of various levels of affluence. Another is the length of time the journal in question has had page charges and the diligence with which it has attempted to educate its contributors in regard to the rationale and functions of page charges. Finally, there are the effects of fluctuations in the general level of funding of research and development work, particularly by government.

For these and perhaps other reasons the fraction of pages for which page charges are paid varies rather erratically from year to year and from journal to journal. These variations merit some study and in fact have often received close scrutiny by journal publishers. We shall not attempt to go into great detail here, but shall merely present, in Figure 25, data that try to eliminate some of the minor or accidental effects by averaging this percentage over several or all of the journals published by a given society publisher. The full and dashed curves in the Figure show such average percentages for half a dozen societies; the dotted curve is for a single journal of another society. Though we have in some cases computed the averages rather imprecisely, it is

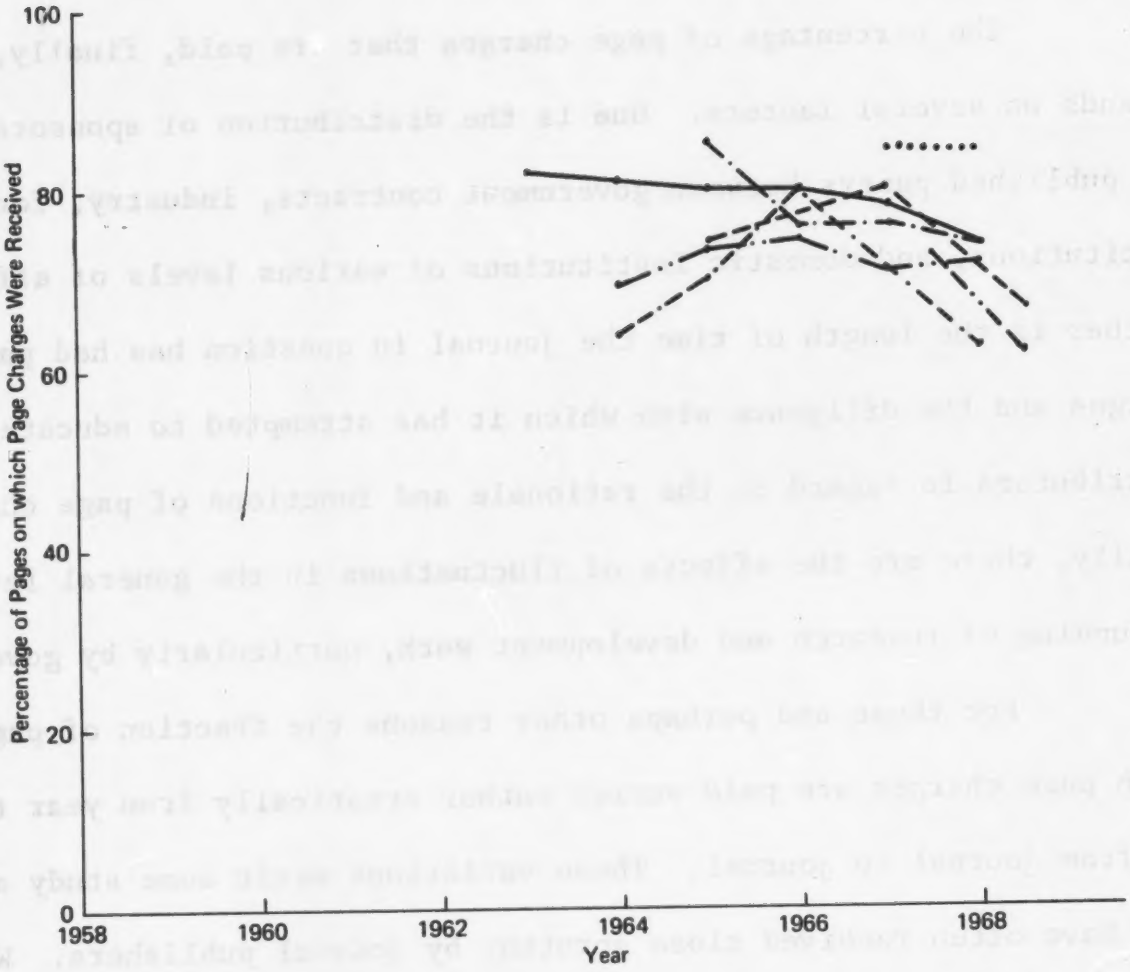


FIGURE 25 Changes with time in the percentage of published pages for which page charges were received. Each curve represents a rough average for several journals published by some one society.

doubtless significant that there seems to have been a rather general decline in 1968. This was undoubtedly due to the cutback in research funds at the end of the year. Although a reversal of this trend in 1969 has been reported by some publishers, including but not limited to those that have inaugurated a potentially slower publication schedule for papers that do not pay page charges (see the discussion of the two-track system in Section IVB.4), it is clear that there is a real danger: The economic stability that the page-charge system confers on journals (see Section IVA.5) could conceivably be destroyed if fluctuations in governmental funding of research and development become too severe and if stabilizing measures (see Section IVB.4) are not taken.

C. Use of Journals

We have already pointed out, in Section II, the importance of studying the nature and frequency of journal use and how the efficiency of use depends on characteristics of the journals. As we mentioned there, the value of the time spent in the use of journals is many times the cost of production of the journals used. In the following subsections, we discuss a number of fragments of information not only about the time invested in the use of journals but also about the role of journals in the transfer of significant information and the ways in which they are used.

1. Extent of Use of Journals

The time spent using primary journals of course varies enormously from individual to individual; it also has systematic variations with level of training, type of activity, field of

specialization, and the like. Even among PhD scientists engaged in research it may vary from a small fraction of an hour a week to 15 hours or more. Since few individuals keep accurate records of their time, studies of this quantity must get their data either from unverifiable estimates or by using random-snooping or random-alarm techniques[39]. An early use of the latter was reported by Martin[9,22] for a sample of 197 chemists and 404 physicists employed in various U.S. academic, governmental, and industrial organizations. He found the average time spent reading periodicals to be 2.0 hours per week, both for his chemists and for his physicists. His samples, despite their large size, may have been atypical; for example, the Journal of the American Chemical Society ranked second (after Physical Review) in amount of time given to it by those they identified as physicists. Scientists doing mainly research were found to spend more than twice as much time reading as nonresearch scientists, namely, 3.3 hours per week for research chemists, 2.7 for research physicists. An earlier study of chemists, quoted in Reference 9, had given a value 2.7 hours per week.

As for studies using questionnaires, Brockis and Cole[40] gave figures on "percentage of project man hours spent on literature searching" for a sample of 27 (chemical?) projects. These ranged from zero to 25 percent; from their table one can infer a mean searching time of a little under seven percent, or approximately 2.7 hours per week per man. As part of the searching time is devoted to secondary sources, and as a sizable part of the normal use of journals does not fall under the heading "searching," it is hard to compare this figure with Martin's two-hour figure quoted above. A more detailed study is that of an

American Chemical Society (ACS) committee[23] that reported estimates by a sizable sample of U.S. industrial chemists that averaged to 5.8 hours per man per week using primary journals, 2.7 hours using books and reviews, and 3.3 hours using various secondary media.

We have already mentioned the finding by Martin[9,22] that "research" scientists read rather more than twice as much in journals as "nonresearch" scientists. He also found a slightly higher reading time for those who had published papers in the last few years. Similar conclusions have been reached by Maizell[41], who studied a group of U.S. industrial chemists: He found very clear positive correlations between amount of journal reading and productivity, as estimated for different individuals in any of several ways. An earlier study by von Zelst and Kerr[42] led to similar conclusions. While these results do not necessarily imply that any measures that increase journal reading will transform less productive people into more productive ones, they do imply that the saving of time resulting from measures that make journal reading easier will be greatest for the most productive segment of the population. Their economic value, therefore, will be greater than that estimated from average figures.

The net import of these studies, as well as of some of our own now under way and of other scattered remarks we have found in the literature, is that the time spent by research scientists in reading primary journals probably varies from an average of a couple of hours a week for some fields to five or more for chemistry, having a positive correlation with research ability, and that the time so spent by engineers is rather less.

It is instructive to compare the value of this time spent in using journals with the cost of producing the journals. In basic research in physics, for example, for which in 1963 the estimated national expenditure was about 500 million dollars[21], the loaded salaries of the physicists involved probably account for about half the total expenditure. The total 1963 cost of U.S. journal-publication activities in physics, very likely including some applied work not relevant to the total just mentioned, probably did not greatly exceed two million dollars. Thus the cost of publication was less than a percent of the salary part of the cost of the research. While the ratio may be different in different fields, it is not likely ever to be very much larger than the figure for physics. If from the preceding discussion we adopt an estimate of five percent of working time devoted to journal reading, we obtain an estimate of over 12 million dollars for the value of the reading time, six times the cost of journal production. While journal reading is international in scope, it is clear that if publication and research activities in other countries scale proportionally, something like this factor six must apply to reading time and publication cost on a worldwide basis.

A different type of study of journals and their use has been made by Garvey and Griffith in the field of psychology[43]. Highlights of this study, conducted by means of questionnaires, include:

(i) The number of members of the American Psychological Association (APA) describing themselves as "regular users" of one of its journals is about ten percent larger than the number subscribing.

(ii) For any particular APA journal, about 20 percent of APA members will scan its table of contents within two months of its appearance.

(iii) Papers vary widely in readership, the maximum being about seven percent of the APA membership, the median (reading or scanning) about one percent.

The American Chemical Society (ACS) has just issued a preliminary report[44] of a similar survey of the readership of Analytical Chemistry and Journal of Organic Chemistry.

2. Characteristics of Journal Use

Browsing and searching. The use of journals is often divided into browsing and searching. Browsing is the scanning of journals, usually newly received ones, to see what material of interest to the scanner they contain; the function it fulfills is sometimes called "current awareness." Searching—a better word, perhaps, would be "mining"—is the retrieval of information that is sought in response to a specific need encountered in one's work. Several studies have undertaken to discover how the reading time discussed in Subsection 1 above is divided between these two activities. Martin's study[9,22] found them to get comparable amounts of time, the percentage of reading time devoted to browsing being 64 percent for chemists, 41 percent for physicists. The ACS study[23] found 72 percent of chemists' journal-reading time devoted to browsing. The APA study[43] found about one third of psychologists' reading to be browsing. These figures perhaps illustrate the fact that one expects the number of hours per week devoted to browsing to vary more strongly from individual to individual, and perhaps even from field to field, than the number devoted to searching.

Another important question one may ask about the use of journals concerns their place in the overall network of information

transfer. We know that much of the transfer of useful information in the scientific and technical community takes place by oral routes, much by preprints and personal correspondence, and the like. How much of it occurs directly via primary journals and how much do such journals contribute indirectly to the effectiveness of the other routes? Fortunately, there have been several studies aimed at finding out how scientists and technologists get the information they find useful to them. The results of five such studies are summarized in Figure 26, in which the lengths of the bars represent the fractions of all items of useful information that come to the recipients by one or another route. It is impressive that all of these agree in assigning a sizable role—on the average nearly one fourth—to the browsing of journals. An essentially equal role seems to be played by personal contacts (generally oral). The "searching" type of journal use is involved in two of the categories shown, namely, the use of abstracts and indexes and leads developed by references in other papers; these two together seem to account for at least as much information as the browsing or the personal-contact methods.

The results of several studies questioning scientists about their information-gathering preferences provide further evidence for the important role of browsing in journals. Martyn[48] queried 647 chemists, physicists, mathematicians, psychologists, and biologists, working in industrial, academic, and government organizations, regarding their estimates of the relative utility of 12 different methods of getting at information in the literature. For the total sample the most favored method was the pursuit of references in other papers, followed

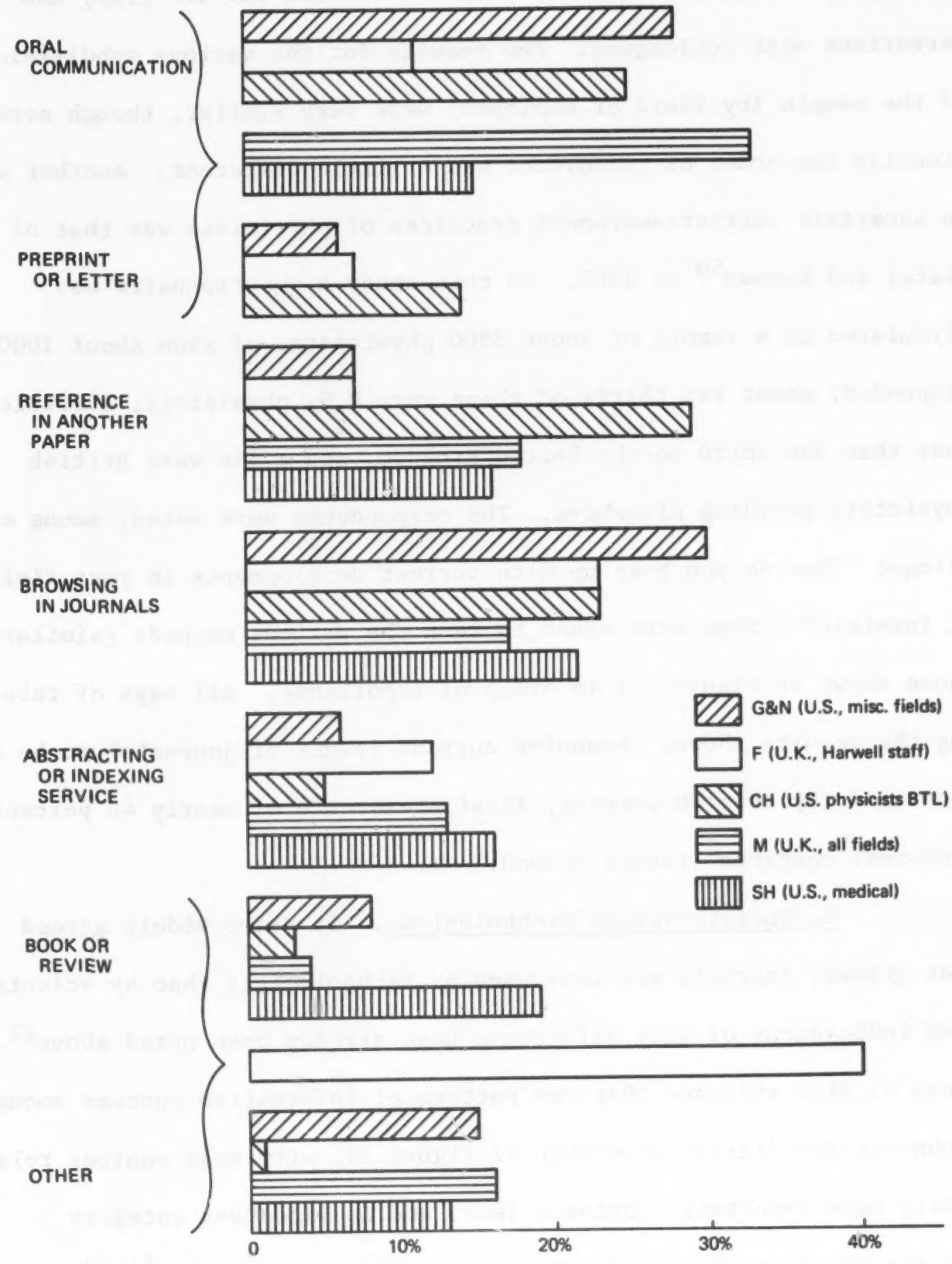


FIGURE 26 Distribution of sources of useful items of information, as found in various studies. The length of each type of bar measures the fraction of useful items that were found to come from the source shown in the study identified by the key at the upper right; the initials refer respectively to studies by Glass and Norwood (G&N),[45] Fishenden (F),[46] Herring (CH),[47] Martyn (M),[48] and Herner (SH).[49]

closely by browsing in journals, use of indexes and the like, and conversations with colleagues. The results for the various subdivisions of the sample (by field or employer) were very similar, though occasionally the order of preference was a little different. Another study to ascertain current-awareness practices of physicists was that of Slater and Keenan[50] in 1967. In this study a questionnaire was circulated to a sample of about 3500 physicists, of whom about 1000 responded; about two thirds of these were U.S. physicists, a little less than one third in the United Kingdom, and a few were British physicists residing elsewhere. The respondents were asked, among other things: "How do you keep up with current developments in your field of interest?" Some were asked to rank the various methods (similar to those shown in Figure 26) in order of importance. All ways of tabulating the results showed "scanning current issues of journals" to be the most used (by over 90 percent, first preference of nearly 40 percent); "personal contacts" ranked second.

Scientists versus technologists. It seems widely agreed that primary journals are less used by technologists than by scientists. Some indications of this difference have already been noted above[22]. There is also evidence that the pattern of information sources among technologists differs from that of Figure 26, with oral sources relatively more important, journals less, and an important category consisting of catalogs and other manufacturer information[51,52].

Degree of specialization: citation patterns. Since journals seem to be an important current-awareness source as well as a reference resource, one may ask how many journals a scientist or technologist

needs to scan regularly. Are people, and journals, so specialized that a given worker can keep in touch with a major part of what is of interest to him by perusing only a handful of journals? A look at the journal population suggests that a small handful, at least, will hardly suffice: Journals overlap tremendously in their coverage. Further information can be obtained from citation patterns in journals. Figure 27 shows, for four major journals, how large a fraction of the citations can be found in the most cited journal (abscissa 1), in the two most cited journals (abscissa 2), and so on. For example, to get three fourths of all citations one must have eight to 14 journals, or perhaps slightly more because of the sampling bias effect described in the Figure caption. It would be interesting to make similar studies of papers cited in large review articles.

It is also interesting, and for some purposes perhaps more significant, to rank journals in the order of the quotient of their probability of being cited in the citing journal by their annual bulk, that is, to rank journal J in the order of the likelihood for a paper of given length, published in journal J, to be cited in the citing journal. Figure 28 shows such data for citations in Section 2 of the Physical Review (solid state). Some of the variations are astounding. For example, the citation rate, per unit bulk, to Soviet Physics - Solid State is less than one tenth that to Soviet Physics JETP or to Journal of the Physics and Chemistry of Solids, and neither circulation nor quality seems adequate to account for the differences. Obviously there is need for further study on patterns of journal use.

A different and probably less meaningful way of studying the range of journals relevant to a given area of interest is to examine

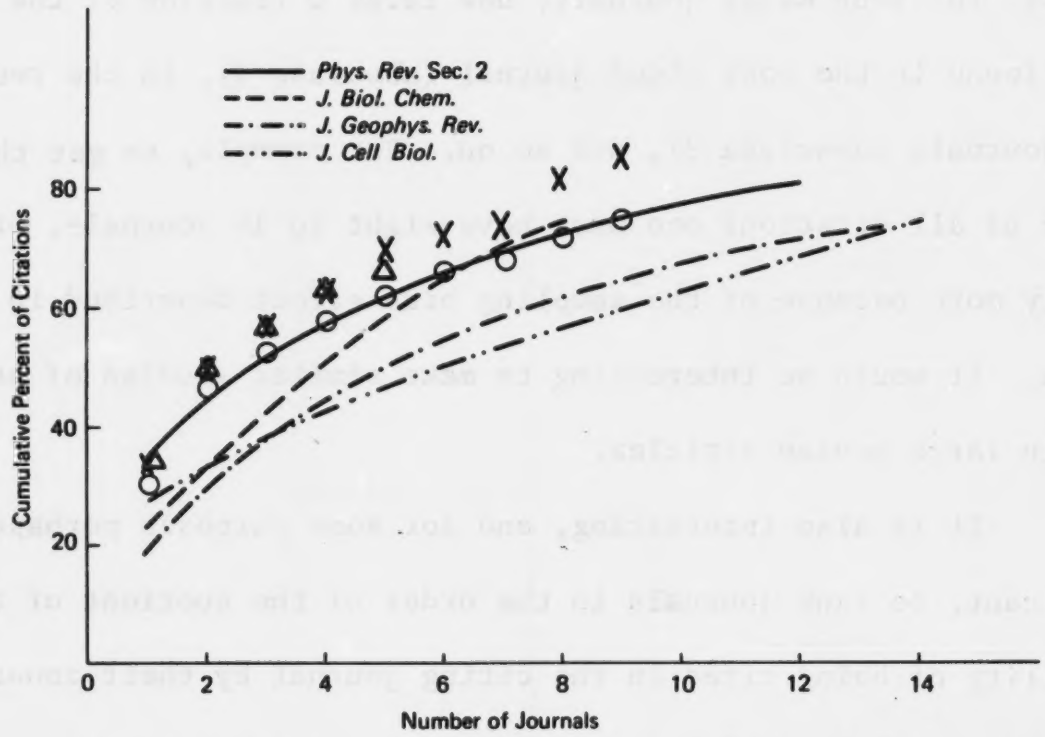


FIGURE 27 Minimum number of journals required to give various percentages of the citations in each of four journals. The solid curve (Physical Review Section 2) refers to a sample of 696 citations. The dashed curves (three other journals) refer to samples of about 160–170 citations. The plotted points (Physical Review Section 2) are for three independent samples of 154–184 citations each and show both the extent of sampling fluctuations and the systematic tendency of small-sample data to give curves lying too high in the right-hand portion.

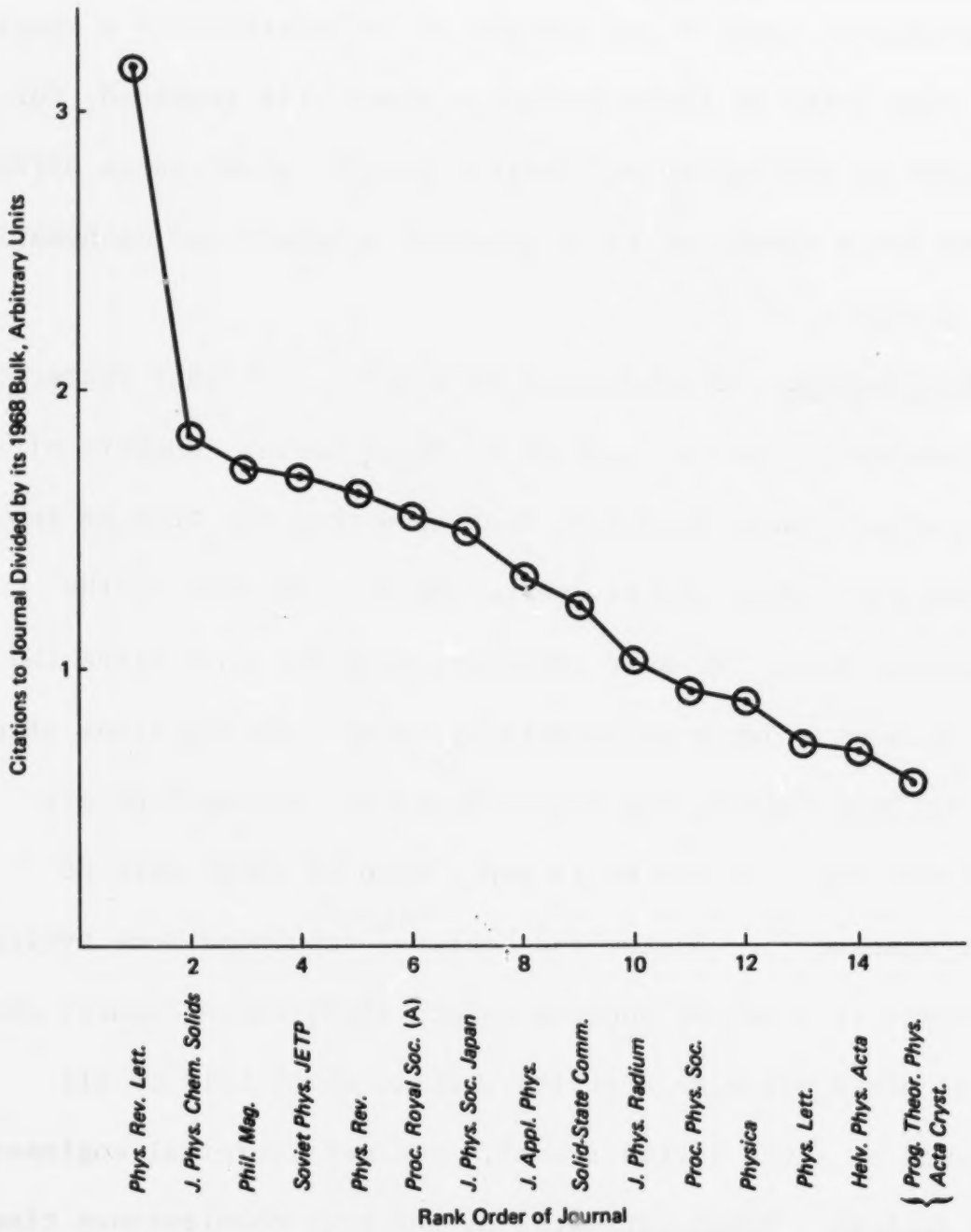


FIGURE 28 Relative frequency of citation of different journals in a sample of Section 2 (the first of the solid-state sections) of the Physical Review in 1968. For each cited journal the number of citations to this journal was divided by the current bulk of this journal to give a number roughly proportional to the probability for a given paper in the given journal to be cited. The journal with the highest value for this probability (Physical Review Letters) was assigned abscissa 1, that with the second highest probability (Journal of the Physics and Chemistry of Solids), abscissa 2, etc. Note that if the two solid-state sections of the Physical Review, which can be separately purchased by members though not by nonmembers, were treated as a separate journal, this journal would probably have abscissa 1 or 2 instead of 5.

the publication patterns of individual authors. A random sampling of authors cited more than about 20 times in the Science Citation Index showed that to cover three fourths of the articles of a single author that were cited at least once in a given year required, for a sample of eight in biological and medical fields, about seven different journals, and for a sample of 13 in physical sciences and mathematics, about three journals.

Obsolescence. Obsolescence is another important characteristic of primary journal papers in relation to their users. Numbers of studies of citation patterns have been made that show that the bulk of the citations made by current papers are to papers published in the relatively recent past. We must remember, however, that since the literature has been growing exponentially, with doubling times of ten to 15 years in most fields, one would expect to find half of all citations within the last ten to 15 years even if there were no obsolescence whatever[53]. Burton and Kebler[54] tabulated some typical figures relevant to a period shortly before 1960; these figures showed the number of years prior to a citing work in which half of all citations could be found varied from 3.9 for metallurgical engineering to 11.8 for geology. Rough estimates of the true obsolescence time can be obtained by correcting these for literature growth. For example, their half-time of 4.6 years for physics citations gives nearly an eight-year obsolescence time after allowance for an 11-year doubling time of the literature. (More recent studies[55] give a slightly shorter half-time for physics citations, however.) Alternatively, a very simple test can be made with the Science Citation Index. In many fields, the number of

times a given paper is cited continues to be, on the average, about the same, year after year; this means that the obsolescence rate is just about cancelled by the rate of growth of citing literature. Further data of this sort have been discussed by Price[53]. The import of such observations is that the obsolescence of much of the primary literature is much slower than is sometimes thought. Interviews with experts asked to evaluate past solid-state physics papers led to a similar conclusion[56].

Dependence of use on availability. An important question for the economic decisions of interest to us is the extent to which the effective use of journals depends on their ready availability. Unfortunately, there are no satisfactory studies aimed directly at this question. Several studies have shown that workers in research and development have a strong tendency to use those information resources that are easiest to use, as opposed to ones that require effort[57,58]. This confirms one's intuitive feeling that journals available in a worker's own office or in a nearby collection will be more effectively used than those available only in a library in another building. We have done a few small studies of citations in physics journals that usually show that an article in a widely circulated journal is more likely to be cited than one in a similar journal of smaller circulation, but we have not yet been able to control various extraneous factors that are likely to be important, such as national clannishness or the tendency of certain topics to concentrate in certain journals.

Missed information. One further type of user study deserves mention. This is the study of missed information—information available

in the literature and of importance to a given research or development project, but that workers on this project did not discover in time to use it effectively. Studies of missed information have usually consisted of queries of the workers involved regarding information that had come to their attention too late[39,45,48,52]. Such studies can give only a lower bound to the amount of missed information, since information completely missed is unrecorded. The most detailed of the studies referred to are those of Martyn[48] (British scientists in various fields) and of Brockis and Cole[40] (British workers in an industrial chemical organization). These found, respectively, that 22 percent and 37 percent of the respondents identified missed information relevant to their projects, with 14 percent and 35 percent, respectively, indicating that an appreciable saving of effort or resources could have resulted if the information had been available at the proper time. The authors of these studies converted these figures—with the aid of other answers from their questionnaires—to crude estimates of the economic loss from the missing of the information. With a guess at unreported missed information and allowance for material that might not have been published in time to be used, Brockis and Cole estimated a loss of the order of one thirtieth of the research budget. Other, presumably more intuitive, estimates of this loss for the whole research and development effort in the United States have run several times higher[60,61]. Even the more conservative estimates of the loss due to inadequate information gathering, however, amount to more than the total amount now spent on information services of all kinds, in which primary journals constitute the largest item.

D. Further Topics

In this section we comment briefly on a number of topics to which we devoted very little attention, but that merit consideration in more comprehensive and detailed future studies. These topics are very diverse; we discuss first the technological ones (Subsections 1 to 3), then a group dealing with financial matters not covered in Section IIIA (Subsection 4), and finally a group having to do with the sociology of publication (Subsections 5 to 8). We make no attempt to give an adequate discussion of the important subject of copyright law and practices, although it is mentioned peripherally in connection with microform and reprography.

1. Printing

Typography, format, and the like can be significant factors in journal economics both because different choices among them can entail different production costs and because they can affect the efficiency with which readers use the journals. We present only a few scattered observations here. Figure 29 shows the distribution of journals of all our samples with respect to number of equivalent words (defined at the start of Section IIIA.1) per page. We see that the commercial and nonprofit journals have a similar distribution, with a median page size a little over 500 words, none under 300, and almost none over 900, while the society journals, though exceedingly diverse, run to larger pages: They range all the way from 300 to 2600 words, with a strong concentration around 1000, the median being slightly under this. As might be expected, type size tends to vary in the oposite direction from words per page: In a subsample of our sample we found

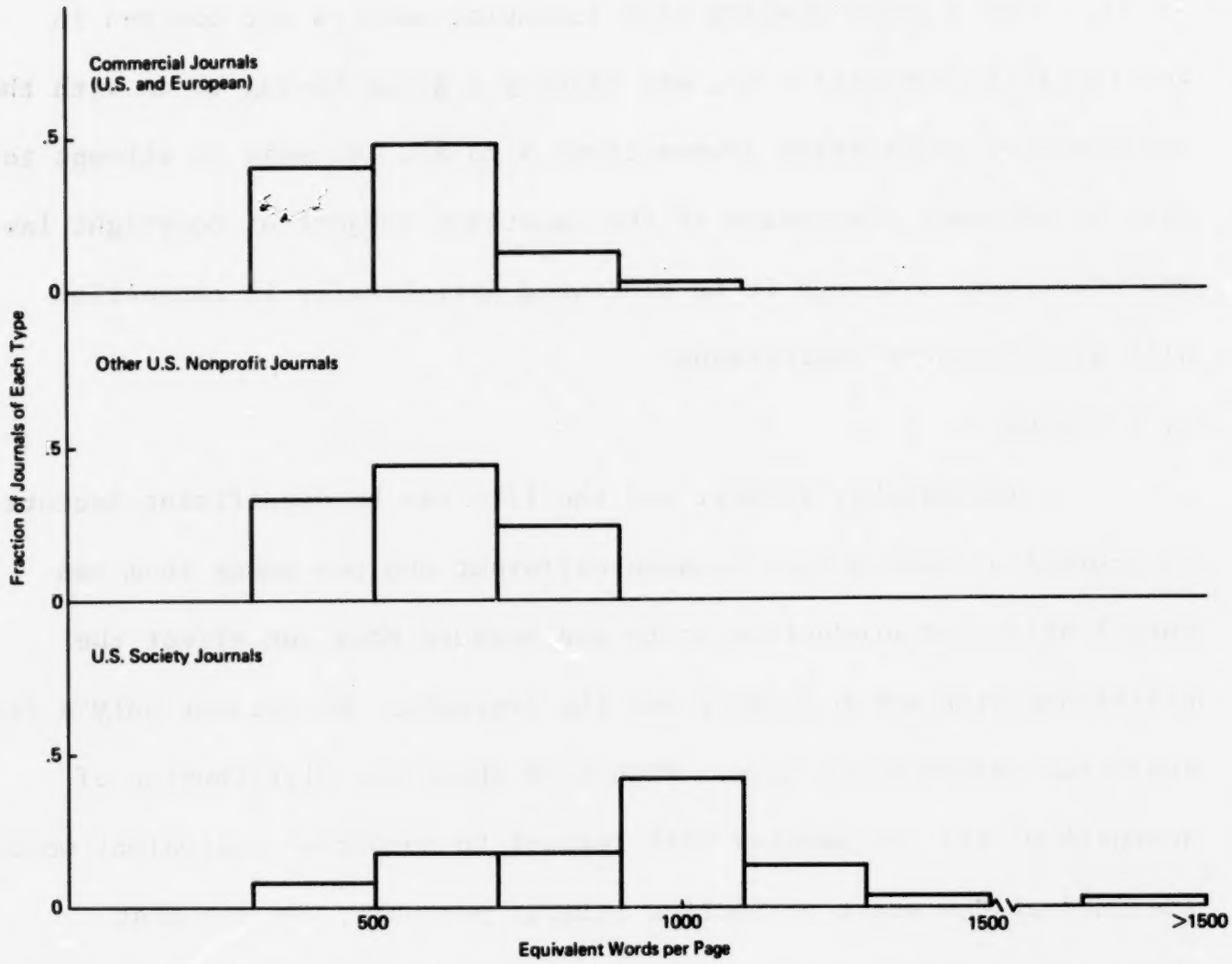


FIGURE 29 Distribution of page sizes among journals of three types of publishers in Sample (1) (described by Section III). All fields are lumped together.

the mean type sizes to be 11.0 points for the U.S. society journals, 11.6 for the commercial journals, and 11.2 for the U.S. nonprofit journals. The smallest type among the 52 journals was nine point (one journal), the largest 12 point (19 journals).

Studies of reader preferences and reading speed have shown that subjective preferences peak at about 11 point, reading speed at about ten point[62]. The figures quoted in the preceding paragraph suggest that the commercial journals have made more effort to cater to what they believe to be a reader preference for slightly larger type, but that the society journals, in their presumably economy-motivated tendency toward smaller type, may actually have a slight edge in legibility. The studies cited[62] do not take into account the need that scientific and technical readers often have to refer to different portions of the text for figures or for previous equations or definitions; these actions can presumably be performed the more efficiently the larger the number of words per page. Studies on this point might be very useful.

The great majority of journals are still printed by conventional methods. A survey of 1969 issues of most of the journals of our Sample (1) showed that, of 247 journals publishing original full-length articles, all but six had justified margins, therefore were set in type for printing either by letterpress or offset—if we can assume that none were done by computer-controlled photocomposition. The six were typewriter composed. On the other hand, every one of the nine letter journals in the sample was typewriter composed as were 15 of the 16 translation journals. Of the 14 societies we queried by letter, only two were using typewriter composition for primary journals devoted to

full-length papers, and only one other mentioned plans for use of this method in the immediate future. One mentioned plans to change from letterpress to offset printing but presumably still with typeset copy. (See the discussion of costs of typewriter composition versus typesetting in Section IIIA.4.)

Though we have not encountered any use of computer-controlled photocomposition for regular journal material, several publishers have told us that they use it for other publications, especially lists, abstract journals, or indexes. At present it is relatively less economical for highly technical material than for more popular magazines that print simple textual material; however, many publishers of scientific and technical journals are eyeing it closely, and some are investigating software for composing mathematical or chemical expressions[36].

2. Microform

Microform has several possible uses, none of which has been fully exploited. The commonest use so far, of course, has been to supply libraries with back-number stocks of journals now out of print. Recently a market has grown up for annual microfilm editions of current journals. When the publishers permit copying of their journals for this purpose, the price, limited only by the production cost of the microfilm, is of the order of one third to two thirds of a cent per page[63]; that is, is comparable with the runoff cost of the paper edition (Figure 11) and usually well below the normal subscription price. Nonprofit publishers whose input costs are largely covered by page charges are the most likely to allow microfilm reproduction to be marketed at close to production cost, since the stability of their operations with respect

to fluctuations in demand allays their fears of economic loss from microfilm competition. In other cases, the publisher may insist on a considerably higher price for the microfilm edition, and sometimes he does not permit copying of issues he can supply on paper.

The microfilm editions we have been discussing appear only at the end of a year—a single issue would be much smaller than present rolls. However, the microfiche card is of a size suitable for single issues of many journals, and in this form publication for current use is possible. Use of microfiche rather than paper editions can vastly reduce storage costs and can make possible airmailing of journals to overseas subscribers. It has been pointed out (e.g., Reference 55) that the compaction of storage space would be especially helpful to individual subscribers. This form of publication is only beginning to be available. One of the pioneers, for example, has been the Institute of Electrical and Electronics Engineers, which, after experimenting with it for a few journals in 1969, has decided to offer microfiche editions of all its primary journals in 1970. The market will undoubtedly take time to build up: Though reasonably satisfactory viewers are now available, they will have to become much more widely so than at present before microform editions can find a large market. Production cost, however, is no problem, as microfiche runoff costs are already competitive with printing on paper.

Another use of microform, which has been adopted by occasional journals (e.g., Mathematics of Computation), is as a supplement to the material printed in the journal. Tables and other appended material can be photographed directly from copy supplied by the authors and

provided to the subscriber on a microfiche card delivered in a pocket inside the cover of each issue of the journal. Only for exceptional journals, however, does the population of articles now appearing in them contain as much as ten percent of material that could be lifted bodily from the articles and subjected to this treatment. Though it has sometimes been suggested that a journal might instruct its authors to write brief articles for printing on paper, accompanied by more detailed versions for the accompanying microfiche, we have not encountered any case where this has been done.

3. Reprography

All the publishers to whom we sent our queries were asked if they had noticed, or anticipated, any effect of the recent boom in reprographic facilities on the demand for their journals. All the answers were rather noncomittal, with language such as:

"We cannot tell how reprography affects us. It cannot be great because we have never had much income from single copy sales or sale of reprints."

"We have no good way of assessing the effect,...but...we have just this year instituted the policy of charging a small royalty fee for the right to reproduce entire articles...."

"We know that copying of articles by xerography is widespread.... We have no way of measuring the impact on journal subscriptions, though we observe that growth in member subscriptions has not kept pace with growth in membership."

"As yet we have no indication that reprography has cut into the demand for our journals, but if uncontrolled copying of journal articles continues, we anticipate a loss in subscriptions in the future."

We have seen in Figure 20 that even the nonmember circulations of society journals have more often been increasing than decreasing. Thus it is understandable that few society publishers can say they have noticed an adverse effect from reprography. However, one society, some of whose journals had suffered a loss in circulation, sent out a questionnaire in 1967 to the subscribers who had discontinued. About a third of those questioned replied, and about a third of the replies listed as at least one reason for dropping their subscriptions "use library or co-worker's copies," and for many of these xeroxing was explicitly mentioned.

There is still disagreement about the legal status of copying. There is a widespread opinion that the "fair use" concept applies to the copying of single papers on request of individual workers who wish the copies for their own use. Some publishers accept this view; some do not; and there are clear differences in the reactions of different types of publishers. Journals with page charges are often, though not always, tolerant of copying and willing to accept whatever consequences it entails. Those without page charges, and especially the commercial ones, more often try to discourage copying as much as possible by proclaiming strict interpretations of their rights under copyright law. Hopefully this legal question will be clarified in the near future by legislation revising the copyright laws.

Copying is of course much more expensive than the making of extra printed copies. The current effective cost of about five cents per page for xeroxing, of which about two thirds is equipment and materials, one third labor, is rather less than the eight cents

reported a few years ago[64], but is still well above the typical one cent or so cost of augmenting a reprint order or the runoff cost of printed material as displayed in Figure 11. The total cost of purchasing a given number of reprints, however, may approach or exceed that for the same number of xerox copies if the number of copies in question is not large. Since authors seem to have a strong interest in sending out unsolicited reprints, reprography has not cut seriously into reprint sales—many journals report steadily rising orders for reprints—though it has greatly decreased the sending of reprint requests to authors. In any event, reprography does not seem to pose any economic threat to selective-dissemination schemes such as that of the Mathematical Offprint Service (see Subsection 7).

4. Differential Costs of Journals to Libraries

Besides the production costs incurred by the publishers, and the hidden costs of refereeing and some other parts of the editorial process, all of which we have discussed in Section IIIA, the cost of journals to society includes such things as the expense incurred by libraries in handling, binding, and storing them and the cost of users' time for reading them. We have said a little about the latter item in Section IIIC, so will comment here only on the former.

Binding costs, of the order of half a cent per kiloword, amount to only a small fraction of most subscription prices (Figure 3). Keeping track of subscriptions and deliveries—one must make inquiries whenever an expected issue fails to appear—adds only a small fraction of a cent per kiloword. Handling of borrowing and reshelving may cost rather more; though it is hard to give a general estimate, as the figures are

very dependent on the nature of the collection and of the user population, it seems likely that these costs may often run to a sizable fraction of the expenditures for subscriptions. Storage costs also vary greatly, but will not usually be much more than one tenth of a cent per kiloword per year. Copying of articles for users, finally, may turn out to be the biggest item of library expense associated with certain popular journals; however, unlike the other items mentioned, it is not an expense that is necessarily incurred by the library through the mere act of subscribing (it may be charged to the user, for example), and we prefer to regard it as a separate operation.

Thus the total cost of journal subscriptions for a library is apt to exceed the amount paid for subscriptions by an amount of the same order as the latter. However, as the largest item on these additional costs is apt to be the labor of providing the journals to their users, these costs will not increase in proportion to the amount of material acquired when the library subscribes to a new journal of marginal interest or gets a duplicate subscription of a high-interest journal. The other large item, storage, depends on the number of years the material is retained.

5. Time Lags and Backlogs

The time lag from receipt of a manuscript at an editor's office until its appearance in print has two, and sometimes three, components. Two components that are always present are the time taken in refereeing and editorial decisions and the time for processing (e.g., copy editing, composition, and printing). If the journal's funds are insufficient to pay immediately for the processing of the material on

hand, or if the printer is overloaded, a waiting period may be necessary, constituting a third contribution to the time lag.

We have not had time to study time lags sufficiently carefully to sort out these contributions from one another. Figure 30 shows some data on the distribution of time lags for a haphazard sample of late 1968 or early 1969 issues of journals of various types and some median lags taken from a published study of backlogs in mathematics journals[65], as of 1967. Although our sample was small, the data suggest several conclusions:

(i) The present technology used for most journals (typeset, letterpress) entails a time lag of a little over three months, when technical editing time is reduced to a minimum.

(ii) The long minimum times for some journals suggest backlogs due to overloading of financial or printing resources. The mathematics study mentioned above[65] confirms that such backlogs are common.

(iii) Time lags vary greatly from journal to journal and seem usually to be determined more by factors peculiar to individual journals than by factors peculiar to fields or types of publisher. However, mathematics and psychology do seem to have longer time lags than the other fields sampled.

(iv) The spread between minimum and median times is a rough measure of the magnitude of typical editorial and refereeing delays. For the journals sampled this spread ranges from less than one month to several months.

About half of the nonmathematics journals sampled supplied two dates of receipt for manuscripts that were revised after their first

submission. In such cases, the more recent date was the one used for the tabulation summarized in Figure 30.

For the other journals, it is not clear whether the date of receipt given is that of an original or that of a revised version. The time interval between those two dates can be very long of course, as it depends on the speed with which the author makes his revisions. This uncertainty will affect the medians in Figure 30, but not the minimum times corresponding to the left-hand ends of the lines. Different journals vary greatly in the extent to which they require or encourage revision of papers submitted to them. For most of the journals that quoted two dates, well over half the articles had undergone revision. Yet for the Physical Review, which has the reputation of maintaining very high standards, only a little over ten percent of the articles were noted as having undergone revision. Part of this difference may be because some journals mention receipt of a revised manuscript if the author makes a tiny adjustment of style or wording, while others do so only if there is a change in the substance of what is said. But there are undoubtedly also real differences from journal to journal in the extent to which the papers submitted measure up to the standards desired by the editors.

It is interesting to compare the time lags for revised versions of papers with those for papers published without revision. The revised papers were published with shorter median time lags than those that did not undergo revision, the difference ranging from half a month to nearly four months in our sample. This presumably reflects the fact that most of the refereeing for the revised papers had already been done

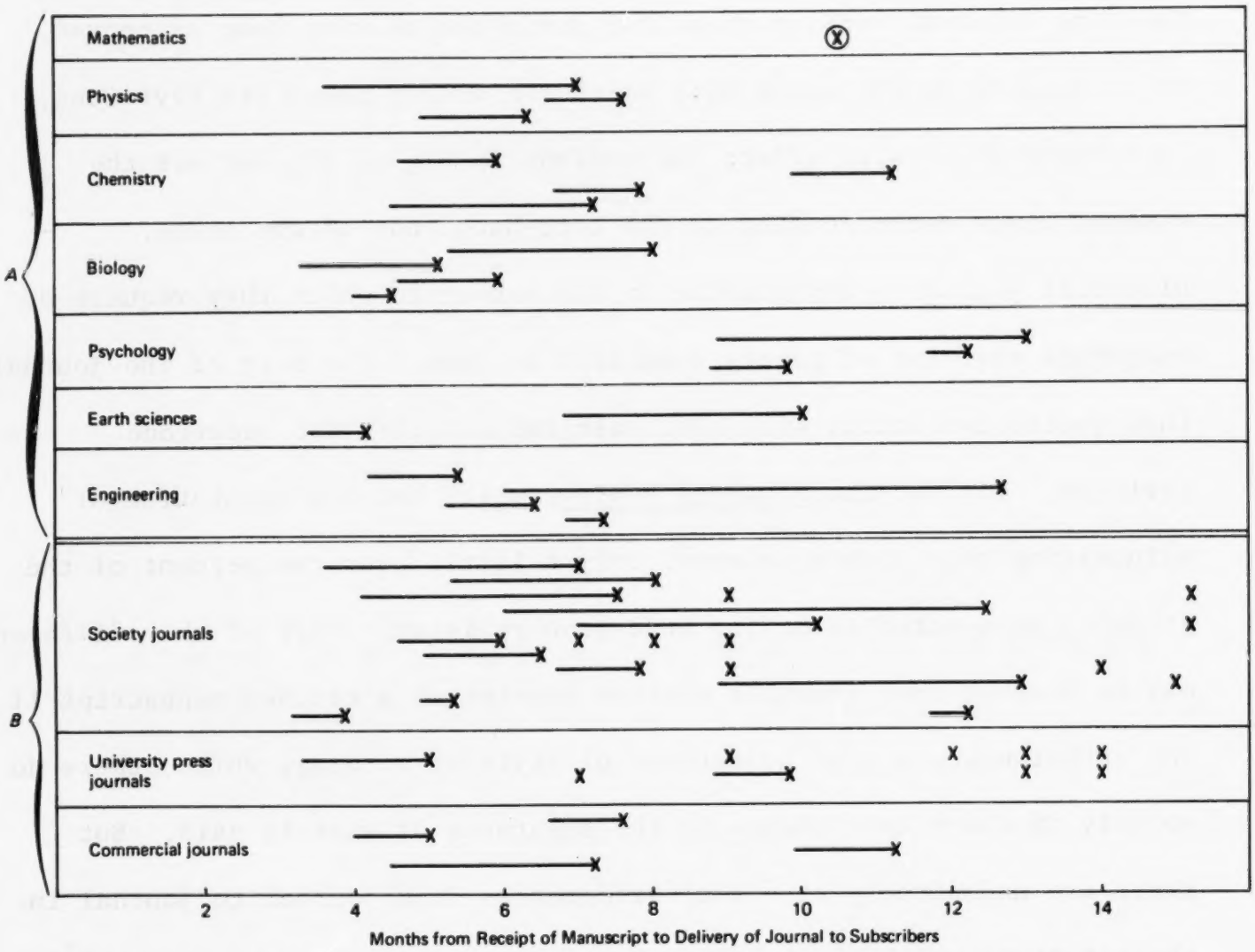


FIGURE 30 Typical time lags in publication for a few journals of various types. The horizontal scale measures the time between receipt of a manuscript (or its revision) at the editor's office and its delivery in printed form to subscribers. The left end of each line is the minimum interval observed in a sample of 20–50 papers from a given journal; the X at the right end is the median interval. For mathematics journals, only the medians are shown; these were taken from Reference 65. In A the journals are separated by fields, and only the median of the median times for all the mathematics journals is given. In B the same journals are shown separated by type of publisher. All data pertain to full-length papers only; letters are not included.

before the revision, so that only a minimum amount of editing had to be done afterward.

All the preceding discussion refers to full-length papers. Short notes and letters, when published in journals devoted mainly to longer papers, usually appear with a slightly smaller median time lag than the latter, but in only one case (Journal of Geophysical Research, 2.3 months), with a minimum time lag shorter than the three months shown in Figure 30 for papers. Letter journals achieve shorter time lags; as we have seen in Subsection 1 above, they are usually typewriter composed and, because of the nature of their material, they usually make a special effort to speed up publication. A brief sampling disclosed minimum time lags of 1.2 months both for a society letter journal (Physical Review Letters) and for a commercial one (Biochemical and Biophysical Research Communications). Not all letter journals do as well as this, however. The median time lag is usually only a fraction of a month longer than the minimum.

It is of some interest to examine the production processes of typical journals in more detail to see what elements go into the typical three-month minimum lag we have noted in Figure 30. Some figures recently presented by Koch[37] for typical (domestic monotype, letterpress) journals of the American Institute of Physics show the following time intervals, the location of each operation being indicated (EO for editorial offices, P for printer, A for author):

Copy marking (EO)	7 days
Composition (P)	29
Galley proof correction (EO,A)	12
Paging (P)	12
Page proof (EO)	5
Printing (P)	20
Total	85 days

To this must be added a few days transit time in the mail.

We have been told that composition overseas adds about a month to the time lag for a journal with editorial offices in the United States. Journals with editorial offices in Europe seem usually to operate on schedules similar to those of U.S. journals. It is noteworthy that the East German journal Physica Status Solidi announces in each issue its pledge to publish manuscripts "within 50 days of acceptance"; its performance overall, however, corresponds to a minimum time lag of 50 or 60 days from receipt of manuscript to nominal issue date, and about two months longer for receipt by U.S. subscribers.

Changes in the technology of composition and printing can shorten some of the components of time lag quoted above. For example, typewriter composition is faster and, being done entirely in the editorial production office, it saves considerable back-and-forth time.

6. National Versus International Tendencies in Publication

Though science is supposed to be international, nationalistic trends are very obviously present. These are due to many factors, for example, language and travel barriers; patterns of personal acquaintance, often originating in the student period; cultural patterns; and the like.

They may often derive from the tendency of most workers to submit their papers to a journal whose editorial offices are close enough for fast mail and telephone communication. In addition, if they subscribe to journals, these are likely to be ones published by their own national society or at least available domestically.

These tendencies are evident in patterns both of publication and citation. For example, the rather sketchy data presented earlier in Figure 17 suggest that only approximately 15 percent of the papers published in U.S. scientific and technical journals are of foreign origin; of course, there is considerable variation in this figure from journal to journal. The percentage of U.S. work published in foreign journals is in most fields probably no greater, though in some (e.g., crystallography) it is very large. In nuclear physics, for example, a field in which several excellent foreign journals are proving especially attractive to U.S. authors, a check of articles listed in a few recent issues of Physics Abstracts shows that nearly three fourths of the articles by U.S. authors are published in U.S. journals.

Figures such as these are of especial importance in relation to the financing of setup costs by page charges. If a very high percentage of the papers a journal publishes turn out to be from foreign authors who cannot pay page charges, the page-charge system will not give the journal very effective support. On the other hand, if foreign authors avoid journals with page charges because they do not wish to be a burden to them, these journals may become undesirably narrow in their offerings to their readers. Again, if U.S. authors are driven to foreign journals through a desire to avoid page charges, their communication with their colleagues may suffer.

Fortunately, the habits of foreign authors do not seem to give cause for alarm on either of the counts just mentioned, at least as far as can be judged from a very brief sampling of journals. In the data collected for Figure 17, the only U.S. journals that were found to be dominated by articles of foreign origin were two commercial journals that, though published in the United States, had the office of the principal editor located abroad. Also, a brief comparison of physics and mathematics journals with and without page charges showed no marked tendency for those without page charges to receive a higher proportion of foreign papers.

The other worrisome pattern—avoidance of U.S. journals by U.S. authors—has started to develop in some fields, but does not yet seem to be of major proportions. (See, for example, the figures cited above for nuclear physics.)

The circulation of journals is of course international. We have obtained the breakdown of circulation into domestic and foreign components for some 19 of the journals of our Sample (2). The median ratio of foreign to domestic subscriptions for this subsample was about 0.40, the extremes being 0.08 and 0.97. Low ratios are apt to be encountered for society journals with a large number of domestic membership subscriptions, high ratios for important journals of low circulation. The absolute number of foreign subscriptions ranged from 434 to 5825, with a median around 1600. Canadian subscriptions, when known, were usually only a small fraction of the foreign total. It is interesting to note that the Physical Review, the largest of all physics journals and the least expensive per word, had a foreign circulation

(a little over 3500) larger than the total circulations of all but one of some 17 European physics journals for which circulation data were available.

7. Repackaging and Selective Dissemination

Although circulation statistics such as those of Figure 5b and Figure 20 indicate that the demise of individual subscriptions to journals is still far off, there is no doubt that in many fields the individual worker feels less and less adequately served by the few journals (if any) to which he subscribes. Judicious subdivision of large journals has undoubtedly helped to combat this trend (see the paragraph at the end of Section IIIB.2). But many people feel that it is necessary to go beyond this to selective-dissemination schemes that will take input material from many journals, select what is likely to be of interest to a particular user or a limited group of users, and deliver it speedily to them. So far, most of these "SDI" schemes that have been developed and put into operation have been schemes set up within a particular industrial or other organization to supply title listings or similar information to users within the organization. Such schemes are hardly within the province of the present study. However, they share some features in common with those that deal with substantive content of journals, which we discuss below, so it is appropriate to direct the interested reader to some recent reviews of them[66,67,68]. Here, we are concerned only with schemes that involve journal publishers fairly directly and offer current delivery of full-text hard copy to at least a major portion of the whole community of subscribers.

Since July 1968, the American Mathematical Society (AMS) has conducted a most interesting experiment in selective dissemination, its Mathematical Offprint Service (MOS)[69]. Subscribers to this service submit an interest profile compounded from categories in a detailed hierarchical subject classification scheme, names of authors to be selected or excluded, and identification of languages or journals to be excluded; logical combinations of these criteria are possible. These subscriber profiles are matched by computer against the characteristics of articles scheduled for publication in all the journals that have agreed to participate (about 80 U.S. and foreign journals), and immediately after the printing of each journal the publisher runs off as many reprints of each article—above those requested by the author—as are needed by MOS. These are sold to AMS at an agreed price and AMS mails them immediately to its MOS subscribers. Also, it provides its subscribers with lists of titles of papers that match a somewhat wider interest profile.

In the first year of operation of MOS, the number of subscribers has grown from about 500 to over 1000, each subscriber receiving on the average something like five offprints each month. As the number of articles processed has been of the order of 500 a month, the average article is provided to only about ten subscribers; as a reprint order as small as this is not convenient for most publishers, a variety of purchasing schemes have been used or considered, and some publishers have refused to participate. However, user response has been such that AMS plans to expand the service and make it ultimately self-supporting. Though this will require a sizable increase in the charge to subscribers

(see next paragraph), many subscribers may purchase it from government contract funds if it proves really valuable—a practice considered legitimate by the supporting agencies because the service is tailored to very specific needs.

In the first year, the total cost of the MOS service came to a little over two dollars per offprint sent out. This cost was several times the income received from subscribers, who had been charged 30 cents per offprint and three cents per title listing, these charges being deducted from an initial 30-dollar deposit. The difference, which was expected in this initial stage, was made up by a grant from the National Science Foundation. The largest item of cost, about half the total, was labor at the AMS offices; in this category, keyboarding and the like of the information on articles was the most important subcategory. Another major item, over a third of the total, was programming and data processing; however, most of this was the initial programming of the system, which is not a cost for continuing operation. Payments to journals for the offprints supplied came to only about 20 cents per offprint. Mailing and handling were only minor items of expense.

It is worth noting, for comparison with these figures, that the Institute for Scientific Information (ISI) offers to supply on request "original article tear sheets" of any current article listed in any of their various secondary services at a price of two dollars (up to 20 pages). These tear sheets are simply taken from multiple copies of the journals that ISI gets from the publishers.

The cost of selective dissemination systems such as MOS of course can vary widely with variations in the number of items processed

and number of subscribers: It should really be accounted in three categories, input cost, matching cost, and output cost. Both input and output costs should include file-maintenance items. The cost is also very dependent on the degree of refinement used in the classification of items. The input and matching costs for an SDI system delivering hard copy are essentially the same as for one supplying only lists of titles. It is interesting to note that the very low total cost figure of five cents per title supplied to a subscriber has been quoted for a British commercial SDI service (Science Documentation Centre, Ltd.)[70]. Unfortunately, this brief note gave no figures on number of subscribers, ratio of items supplied to items of input, or the nature of the subject breakdown used; thus the real meaning of the cost quoted is uncertain. The minimum conceivable labor cost of input, that of keyboarding a title and reference for each paper, might be of the order of 25 cents per item of input.

The MOS system described above is individually tailored for each subscriber; it is expensive primarily because of the keyboarding and programming required to match articles with subscribers, and secondarily because of the need to handle and mail individual packages and because of the smallness of the reprint orders, which the publishers cannot handle efficiently. An alternative scheme is to prepare collections of papers that, rather than matching the input profiles of single individuals, fall in a general area of interest shared by a sizable group of specialists. Swanson[71] suggested a few years ago that such collections culled from many different journals of the existing type (whose publication would continue) could be published as

specialized journals for many different user groups. The American Institute of Physics is investigating a practical scheme for implementing this idea[72]. Each of a large number of such "user journals" would make a selection from articles scheduled for publication in all of the many conventional journals that participate and would decide at the galley-proof stage which articles were appropriate for its readership. These could then be assembled and printed almost simultaneously with the original journal. While it does not seem likely that editorial costs could ever be made low enough to realize Swanson's[71] estimate of costs for such a system as only a tenth of those for an individual SDI system like MOS, it is very possible that it would be economically viable. In physics, for example, there is a large potential market among the two thirds to three fourths of the membership of the American Physical Society who do not now subscribe to any of the sections of the Physical Review.

In connection with the suggestion just discussed, it is worth noting that the National Aeronautics and Space Administration, after experimenting with a title-listing SDI tailored to individual profiles, has opted in favor of one based on a few hundred group profiles.

8. Tax Exemption

Scientific and technical societies, and other nonprofit organizations that publish journals, receive an effective governmental subsidy, as compared with the operations of commercial publishers, by virtue of their tax-exempt status. The largest item in this subsidy is usually the exemption from local taxes on real property, but even this never amounts to more than a small fraction of the total production

cost of a journal. According to figures kindly supplied us by the American Institute of Physics, which are probably typical for editorial and production offices in large cities, exemption from local real estate taxes allows the budget item for "cost of space occupied" to be only about 80 percent of what it would be for a commercial publisher. According to Figure 8 and Sections IIIA.4 and IIIA.5, the space cost to which this factor of 0.8 applies (upper rows only in Figure 8) is typically a small fraction of the prerun cost and an even smaller fraction of the runoff. Thus the total effect, though perceptible, is very small.

Corporate income taxes affect only the net income in a year of operation, which will usually be small for a nonprofit journal and can be offset by losses suffered in prior years. Treatment of advertising income as taxable, because unrelated to the tax-exempt activity, could force major readjustments on those few truly primary journals that support themselves largely from advertising. But in most cases (see Section IIIA.6 above) advertising income is not important enough for its taxation or exemption to be a major factor.

IV. ARGUMENTS AND CONCLUSIONS

A. Factors Underlying the Evaluation of Mechanisms for Support of Journals

Now we are ready to come to grips with the most worrisome of the questions posed in Section I: Should the setup or prerun costs of journal production be supported in a different way from runoff costs, and what should this way be? We seek a support policy that will come as close as possible to doing three things. First, as follows from an idealized application of the principles stated in Section II, the pricing policy should maximize the net benefit to society resulting from decisions of enlightened buyers as to whether they should subscribe to journals. This would be the sole desideratum if the character of each journal could be assumed given and independent of the pricing policy, if the potential buyers could be assumed to provide an adequate collective judgment on the social value of each journal, and if changes could always be made instantly and painlessly. Since these assumptions are not true in the real world, we desire, as a second goal, that the support policy be such as to encourage correct decisions—again as judged by the criteria discussed in Section II—on the whole range of factors having to do with the birth, death, and quality of primary journals. And as a third goal, we desire that the journals have reasonable economic stability in the face of temporary fluctuations in conditions.

It is well to reiterate a basic presupposition stated in Section II: The nation's research and development budget is assumed given, and we seek optimum policies for deciding what fraction of this

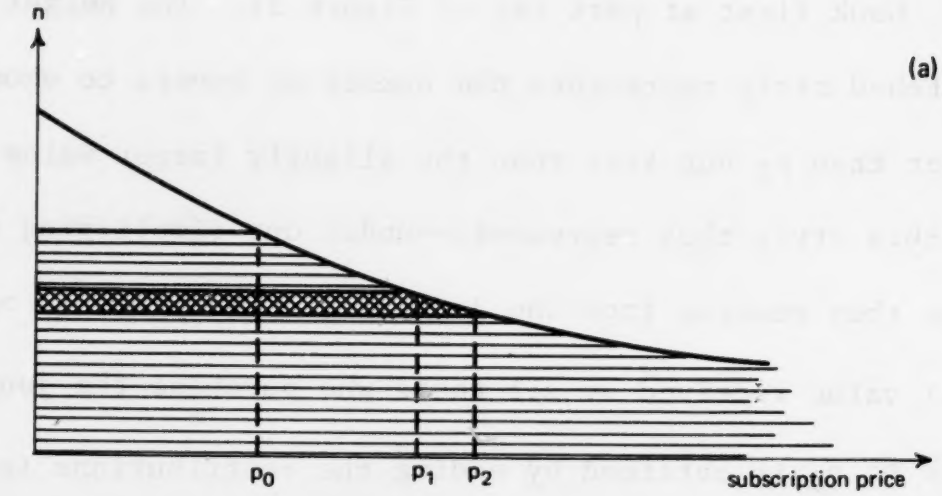
amount is to be devoted to journal publication, and through what channels. The value of the money devoted to journals is measured by the other research and development uses to which it might alternatively be put. As the fraction devoted to journals will never be large, and as the alternatives we shall consider will produce only moderate changes in the total efficiency of all research and development work, it will be adequate to assume that the value of a research and development dollar is a constant and to compare alternatives on a scale of net dollar value.

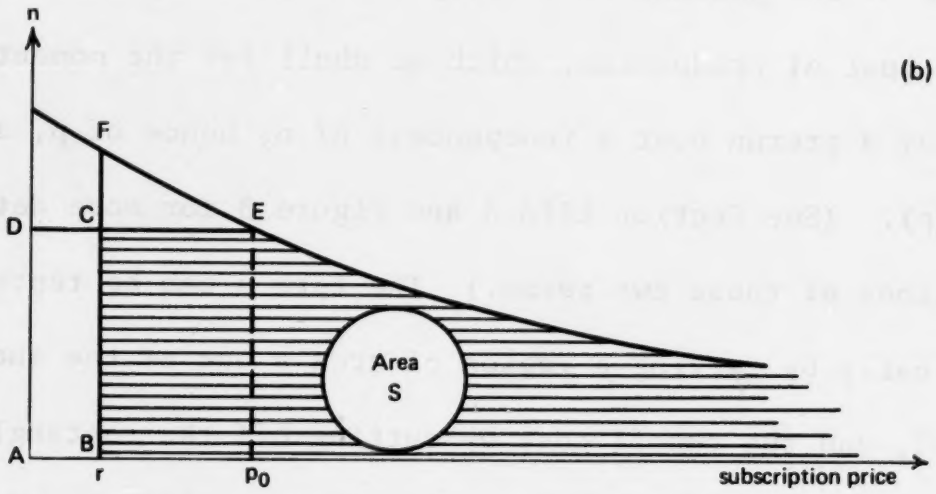
1. Income and Net Value Versus Price

Let us begin by adopting the simplifying assumptions mentioned in the first paragraph above, according to which we have only to balance value received, as judged by the buyers, against production costs. Let n(p) be the number of subscribers to a journal when the price is p, that is, the number of possible subscribers who consider the value of the journal to themselves to exceed p. This function is the "demand curve" of economic theory[19], except that we have chosen to plot prices horizontally instead of vertically. Its form in practical cases can be roughly estimated from Figure 7. For simplicity we shall assume that the price p is the same to all buyers; we thus ignore for the present the frequent distinction between "member" and "nonmember" subscribers. It will now be a simple matter to derive from the curve n(p) the net value of the journal to society. We shall give the argument twice, first in geometrical terms and then in equations that we can conveniently augment by terms which, though we shall ignore them until Subsection 4, will serve as a reminder that our assumptions of the moment are somewhat oversimplified.

Look first at part (a) of Figure 31. The height of the little cross-hatched strip represents the number of buyers to whom the value is greater than p_1 but less than the slightly larger value p_2. The area of this strip thus represents—under our simplifying assumptions—the value they receive from the journal (if the price is below p_1). The total value received by all those who purchase the journal when it is priced at p_0 is obtained by adding the contributions from many such horizontal strips and is, therefore, the total shaded area. The net value of the journal to society is obtained by subtracting from this the cost of production, which we shall for the moment assume to consist of a prerun cost s independent of n, hence of p, and a runoff cost rn(p). (See Section IIIA.3 and Figure 8 for more detailed descriptions of these two terms.) The term s can be represented geometrically by carving a region of area s out of the shaded area in Figure 31, and the runoff cost by cutting off the rectangle ABCD, as shown in part (b) of the Figure. The horizontally shaded area remaining in part (b) is thus the net value when the price is set at p_0.

It would be interesting to evaluate this area numerically for real journals, even though, as we shall show in Subsection 6 and elsewhere, a realistic estimate of value requires rather sizable corrections to the area given by this simple model. Unfortunately, our empirical information about the n(p) curve, which we discussed in Section IIIA.2, is entirely confined to the low-p end; there are some buyers who would pay an extremely high price, but we know almost nothing about the right-hand tail of the curve, which may well contribute a large part of the total shaded area of Figure 31(b). An assumption





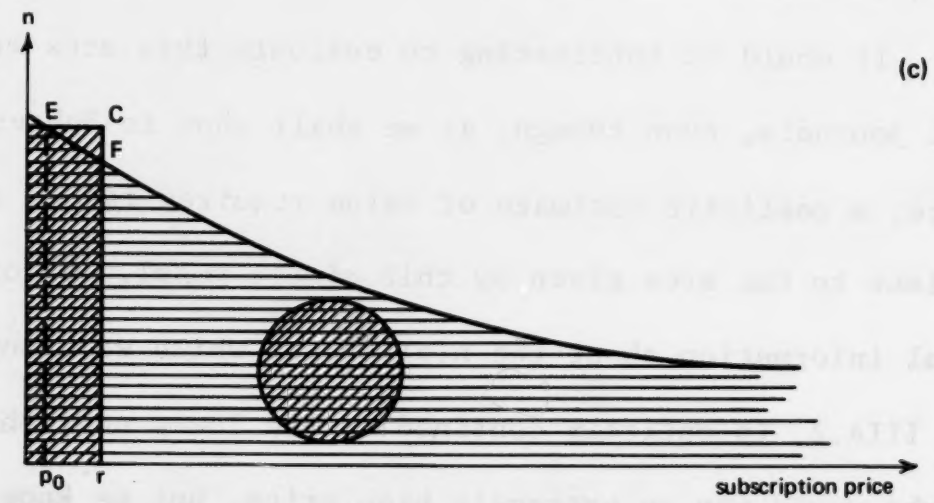


FIGURE 31 Geometrical representation of the social value of a journal, according to a simplified model based on the function n(p) giving the circulation at price p. Part (a): gross value to a limited class of buyers (cross-hatched) and to all buyers (total shaded area) when marketed at price p_0. Part (b): net value to society (shaded areas) if prerun cost is s and runoff cost r per copy. Part (c): gross value (horizontally shaded) and cost (diagonally shaded) when $p_0 < r$.

that would probably underestimate the area in the tail would be to assume the exponential form represented by the dashed curve in the physics part of Figure 7. This would give an uncorrected gross value of about 400 dollars per kiloword, or an uncorrected net value of about 320 dollars per kiloword, if the journal is marketed at a price equal to runoff cost, say 0.3 cents per kiloword. As we shall see in Subsection 6, the true value probably exceeds this by something like a factor two, in addition to any correction due to departure of the tail of the true n(p) function from the exponential form. It is interesting that, although there are these many uncertainties, the estimate of value one reaches in this way is similar to that obtained in Section IIIC.1 on the basis of time spent by users.

Returning from the specific to the general, we note an important corollary of the geometrical expression for net value that we have just derived in Figure 31. It is clear from (b) of the figure that when, as shown, $p_0 > r$, the net value of the journal to society—the shaded area—increases as the price p_0 charged for the journal is decreased to r. Offering the journal at a price $p_0 > r$ entails a net loss to society that, under the simplified assumptions we are using, is equal to the area of the roughly triangular region CEF. It is easily shown that marketing at a $p_0 < r$ also entails a loss to society as compared with $p = r$. This case is shown in part (c) of the figure; the net loss to society is the area CFE. Thus we have the important conclusion: <u>When the prices buyers are willing to pay reflect correct judgments of the value of journals, and if the existence and properties of journals are assumed independent of pricing policy, the progress of science and</u>

technology is optimized by a policy that sets the price to buyers at the runoff cost and supports prerun costs in some other way.

The effects of departures from the ideal conditions just assumed will be discussed at length in Subsections 3 to 7; however, prior to this discussion we will compare the pricing policy just described with two others that are often considered. The two curves of Figure 32 show respectively, as functions of the price p at which a journal is offered for sale, the subscription income, pn(p), and the cost to the publisher of producing it, s + rn(p). If the publisher of the journal wishes simply to maximize his profit, he will set the price at the point where the slopes of the income and cost curves are equal; that is, at the position shown by the vertical line at the right. Note that this maximum-profit point is necessarily past the maximum of the revenue curve pn(p), hence where n(p) is considerably less than its value for p near zero [less than half, if the curve representing n(p) is concave upward, as the evidence of Figure 7 seems to suggest]. Another possible pricing scheme is that of a nonprofit publisher who has to depend entirely on subscription income. Such a publisher will set his price at the point where cost and income are equal, that is, at the middle vertical line. The left-hand vertical line, finally, corresponds to the subsidized publication of the preceding paragraph, which is marketed at runoff cost. Figure 32 provides a useful starting point for the discussion that follows of the effects of changes in journals on their income and other properties.

In concluding this subsection, we shall give a few equations that embody the reasoning we have expounded geometrically in Figure 31

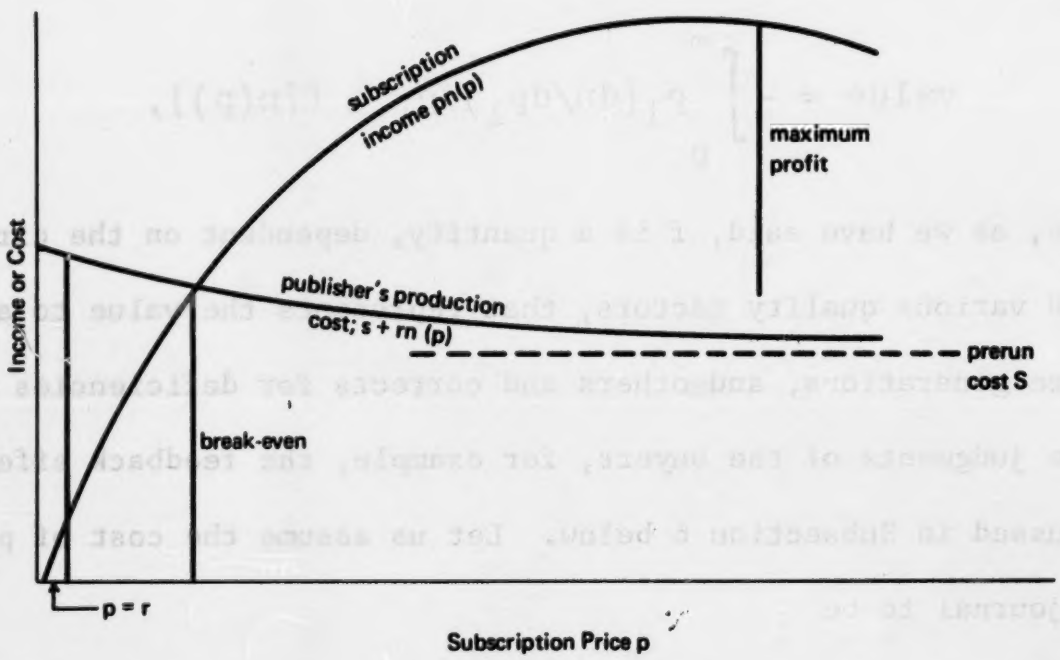


FIGURE 32 Terms in publishers' profit or loss, according to assumptions described in Section IVA.1.

and into which we can insert terms representing some of the effects we neglected there. In terms of our circulation-price function n(p), the number of buyers who assess the value of the journal to themselves in the range p to p + dp is - (dn/dp)dp. The gross value delivered by the journal to society can be expressed as an integral of p times this number plus a correction term f, the presence of which is a reminder that the value judgments of buyers are not the only component of total social value. Thus

$$\text{value} = -\int_{p}^{\infty} p_1(dn/dp_1)dp_1 + f[n(p)], \qquad (1)$$

where, as we have said, f is a quantity, dependent on the circulation n and various quality factors, that represents the value to authors, future generations, and others and corrects for deficiencies in the value judgments of the buyers, for example, the feedback effect to be discussed in Subsection 6 below. Let us assume the cost of producing the journal to be

$$\text{cost} = s + rn(p) + h, \qquad (2)$$

where s is the total setup or prerun cost, r is the runoff cost per copy, and h, which like f we have been ignoring so far, represents the hidden costs plus any profits retained by the publisher. (The definitions of s and r have been discussed at length in Section IIIA.3 and Figure 8.)

If we combine Equation (2) with a partial integration of Equation (1), we get

net value of journal to society ≡ value-cost

$$= (p-r)n(p) + \int_{p}^{\infty} n(p_1)dp_1 - s - h + f \qquad (3)$$

This, if we neglect the h and f terms, will be recognized as the shaded area in Figure 31(b). It is maximized when

$$\frac{d}{dp} \text{ (value-cost)} = 0,$$

that is, if we neglect f and assume h independent of p,

$$p \frac{dn}{dp} - r \frac{dn}{dp} = 0, \quad \text{or} \quad p = r. \qquad (4)$$

2. Decisions and Who Should Have a Voice

It is now time to bring our picture a little closer to reality by considering the managerial decisions involved in creating and publishing journals and how sensitive the mechanisms influencing these decisions are to price and support policies. Can the influence of these policies on the likelihood of socially wise decisions be great enough to outweigh the simple economic argument of the preceding subsection?

One of the decisions is trivial and need not be discussed further: This is the decision on how many copies to produce; it is determined by the economics of buyer response to whatever price is set, though of course some allowance must be made for back-number stocks. The other types of decisions can be grouped as follows:

What journals? When should a new journal be started, or an existing one be split or discontinued?

What papers? What material and how much of it should a given journal publish?

What schedule and format? For example, should the journal be monthly or quarterly? How extensive should abstracts be?

What mode of financing? How much of the needed income should be sought from page charges, from subscriptions, from advertising, and other sources?

Improvements. When should organizational and technological and other innovations be made?

Efficiency. How can production of the journal be made more efficient?

As we have indicated in Section II, we believe that, if one wants correct decisions to be made on such questions, one should adopt general policies that will enable as many as possible of the people with a legitimate concern in each decision to have a voice in it. (This need not preclude making allowance at the policy level for systematic shortcomings in the judgments of these people, if such shortcomings can be demonstrated.) Who are the people with "legitimate concerns?" They are:

Users and buyers. These two words are not synonymous, but as the buyers usually represent the users, it is appropriate to group them together. Users may be subdivided into present users and future users. On a different plane, users, or more appropriately buyers, may be subdivided into those of high interest (individual buyers vitally interested in the area of a journal, large institutions buying their first copy, and the like) and those of marginal interest (moderately interested individual buyers, institutions buying duplicate subscriptions, and the like).

Authors and sponsors. Here again the two words are not synonymous, but are conveniently considered together. Sponsors may be universities, governmental agencies, foundations, or industrial organizations.

All these people have some concern with all of the decisions, but the distribution of concern varies. Thus, present high-interest users are the ones most concerned with the "what journals" question. Sponsors have the most important concern for the "what papers" question, since an investment in research or basic development is largely wasted if there is no provision for publication of the results. Marginal-interest buyers are especially concerned with circulation; efficiency of management is also of special concern to them, since an inefficient operation can price them out of the market. (Note that marginal-interest buyers can be representatives of high-interest users, as in the case of multiple institutional subscriptions to a journal.) Future users, whose relative importance is related to the obsolescence rates discussed in Section IIIC.2, are motivated in favor of large library circulations, since they are inconvenienced if they need to use an old journal their library did not acquire. Authors, too, have a strong interest in wide dissemination of their papers; they also benefit from being able to publish their work in adequate detail and from short publication time lags.

The decisions made by the managers of journals are motivated in varying degrees by economic pressures and by sincere desires to optimize the net gain to society resulting from the operation of their journals; often, too, the most influential consideration is the net gain to some small part of the scientific and technical community.

It will be helpful, therefore, if we can find broad policies for journal financing that, besides coming close to optimizing the net benefit to society and providing reasonable stability, will cause as great a parallelism as possible between motivation for the net value of a journal to society and motivation for improvement of its financial position. In the next few subsections, we compare various policies from this point of view.

2. Financial Motivations for Decisions: Role of Buyers

We are faced with the difficult problems of (a) assigning a dollar value to the effect of any proposed pricing and support policy on the probability of wise decisions of any of the above types and (b) comparing this with the magnitude of the damage done by nonoptimum circulation entailed by any policy that causes price to differ from runoff cost. If we are willing to accept the value judgments of buyers, we can estimate the latter quantity from what knowledge we may have of the subscriber response function n(p). For example, if the runoff cost is trivially small, a sizable increase of subscription price above runoff will eliminate from the market only those potential subscribers for whom the value of the journal is small anyway and will not entail much loss to society.

We have seen in Subsection 1 that, if we use the simple model described in connection with Figure 31, a journal marketed at a price p greater than its runoff cost r yields a net value to society that is less than if it were marketed at p = r, by the amount corresponding to the area of the region CEF in Figure 31 (b). Equivalently, we can use Equation (3), with neglect of f and with the assumption that h is independent of p.

Loss in net value, due to setting price p above runoff cost r

$$= \int_{r}^{p} n(p_1)dp_1 \approx (p-r)n(p). \qquad (5)$$

As we shall show for a typical example in Section IVB.1, the quantity (5) can be appreciable, even for nonprofit journals. The importance of right decisions of the four types enumerated in Subsection 2 is on the scale of the shaded area in Figure 31(a). Thus, for example, an innovation that would increase the value of the journal to all users by 50 percent would typically add a net worth equal to a sizable part of this shaded area, though of course dependent on r and s, since, besides possibly changing unit costs, the innovation would change runoff costs by raising circulation and prerun costs by affecting the number of pages submitted. Using this area as a scale of what are "significant" improvements in journals, we now examine the question whether economic pressures associated with pricing at well above runoff costs can increase the likelihood of significant improvements. The next few paragraphs will present several lines of evidence, derivable from the facts presented in Section III, that suggest a negative answer for many types of decisions but a need for more careful study of at least one type.

Let us begin with the "what journals" question. As Figure 3 and the text of Section IIIA.2 showed, the spread in prices of different journals is enormous when expressed in terms of the cost of a given amount of material. While the circulations of the expensive journals are considerably below those of inexpensive ones in the same field (see Figure 7), they are not low enough to prevent these

journals from making a profit (they are usually issued by private publishers). While expensive journals occasionally fulfill a real need, many or most of the existing ones would undoubtedly receive negative votes in regard to their continued existence if one could get an honest evaluation of them from their potential users. Typically, if a small group of scientists can be interested in a new journal, even though this group is not large enough to provide by itself for the full cost of publication, the journal can publish enough significant papers that libraries in major institutions dare not risk being without it (though they will not buy duplicate subscriptions). Thus, although the majority of the users of this published material might greatly prefer to have it appear in a cheaper, established journal, their institutions will pay an exorbitant price for the new journal rather than miss the material altogether. This conclusion is supported by the fact, noted in Section IVB.1 and verifiable by a perusal of the holdings of any moderately large library, that U.S. journals of the type considered in this study almost never die. They may change name or split, but they nearly always continue. In the rare cases in which they do not, the decisive factors are likely to be other than economic ones. We conclude that buyer response is not very effective in limiting the proliferation of uneconomic journals even when they depend entirely on subscription income. (A further analysis of the economic viability of journals appears in Attachment C.) Socially beneficial decisions on the initiation and discontinuance of journals must depend mainly on noneconomic motivations. (Subsection 7 presents a discussion of the factors on which net social benefit will depend.)

The effects of buyer response on decisions about pricing and financing of journals are also rather simple. Buyer response is practically unaffected by the imposition or avoidance of page charges, except insofar as the material submitted by authors is affected, so the page-charge decision need not be discussed until we take up the influence of authors in Subsection 4. But buyers do respond to prices. As we have already noted, the financial position of a journal improves with increasing price up to the maximum point of Figure 32, while beyond the runoff level such price increases lessen the social value. But for a nonprofit journal, this antisocial effect is quite limited because the price cannot rise beyond the break-even point.

Now let us turn to the effects of economic pressure from buyers on efficiency, that is, on decisions that a publisher might make to produce a journal of given characteristics more economically. It is often argued that the economic incentive of producers of a commodity to reduce their production costs will benefit consumers, since the lower the production cost the lower the selling price at which the producer maximizes his profit. In the case of journals, this is true for improvements in the efficiency of the runoff part of the production process, but it is not true for improvements in the prerun efficiency. The prerun cost, being independent of the size of the market, does not affect the selling price at which profit is maximized, thus the profit motive, though it encourages efficiency, does not in itself cause any benefit from improved prerun efficiency to be felt by users of a journal. Its effectiveness in motivating prerun efficiency is the same whatever the selling price.

We look next at the question of runoff efficiency. Figure 33, like Figure 32, shows schematically the dependence of subscription income and that of costs on price. As we have seen, a publisher desirous of maximizing his profit will set his price at the point indicated by the vertical line labeled "profit," where the difference of the two curves is at a maximum. If the publisher can cut his runoff cost by half, the new cost curve will be as shown in the dashed line, but the dashed-line profit will be only slightly larger than before, because the operating point that maximizes profit necessarily lies where the number of subscriptions is fairly small, that is, a little past the maximum of the "subscription income" curve. Consider, however, the situation of a subsidized journal with a fixed subscription price. Such a journal takes a loss on its sales to subscribers, as shown by the vertical line labeled "loss"; this loss is greatly reduced when runoff cost is decreased by half, because the operating point is in a range where the number of subscriptions is large. Thus <u>the economic motivation for a publisher to improve runoff efficiency is somewhat greater when the subscription price is low than when it is high</u>.

In the areas we have just discussed, it appears that the purely economic pressures arising from buyer judgments are not very effective in motivating other than circulation decisions by publishers and that such effect as they have is most beneficial when price is low and circulation high. Under these conditions, it is the marginal-interest buyers—those willing to pay only a low price—whose judgments carry most weight. As we have noted, however, these buyers may often represent high-interest <u>users</u>, as in the case of purchase of duplicate subscriptions

by large organizations. Another important area, however, in which economic pressure by buyers is, at least theoretically, more important and is likely to be less effective at low price than at high involves decisions that affect the quality of a journal and sometimes the prerun cost—for example, decisions on schedule and format or innovations. Let us first suppose that the decisions are to be put into effect on a short time scale, so that no immediate adjustment of price can be made. If q is a measure of quality, we then have, from Equation (3) and Figure 31,

$$\frac{\partial}{\partial q}\,(\text{net value to society}) = (p-r)\,\frac{\partial n(p)}{\partial q} + \int_{p}^{\infty} \frac{\partial n(p_1)}{\partial q}\,dp_1 - \frac{\partial s}{\partial q} + \frac{\partial f}{\partial q} + \frac{\partial f}{\partial n}\,\frac{\partial n}{\partial q}\,, \quad (6)$$

which, if the f terms are omitted, can be represented graphically by the sum of the two shaded areas in Figure 34; at the same time,

$$\frac{\partial(\text{profit})}{\partial q} = (p-r)\,\frac{\partial n(p)}{\partial q} - \frac{\partial s}{\partial q}\,, \quad (7)$$

that is, the rectangular (horizontally shaded) area in Figure 34. If (6) is positive while (7) is negative, the economic pressure on the publisher will be antisocial; this will always occur if the price p is sufficiently close to the runoff cost r. The maximum of (6), like that of (3), occurs at p = r (if n and $\partial n/\partial q$ are monotonic), but a socially desirable quality change without a change of price may be

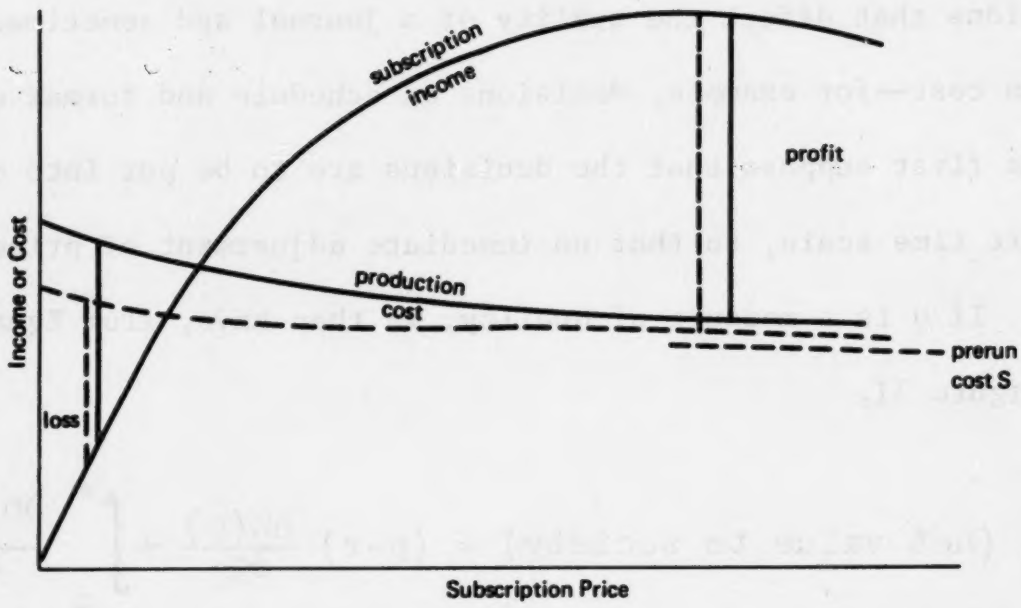


FIGURE 33 Effect of halving runoff cost on profit or loss for two hypothetical publishers.

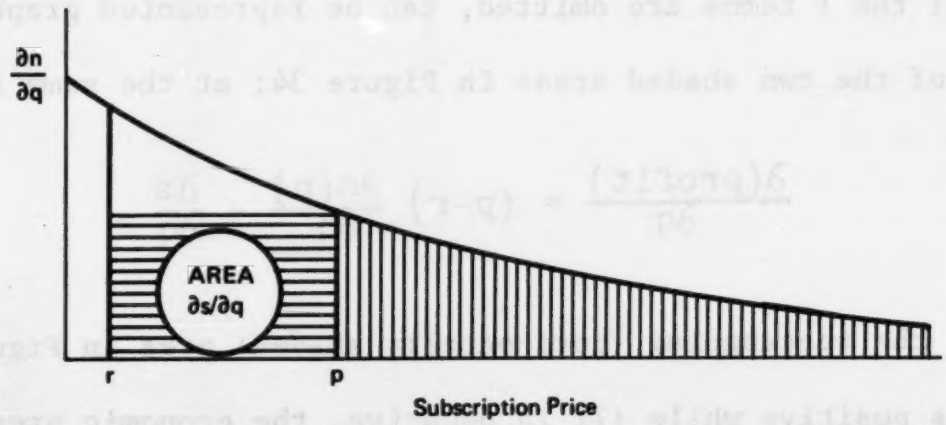


FIGURE 34 Effect of a quality change, at constant price, on social value and on profit. The total shaded area measures the sensitivity of net social value to a quality parameter q; the horizontally shaded area, the sensitivity of profit to q.

financially disadvantageous to a publisher unless the price is significantly above the runoff cost.

This last conclusion is considerably softened if the quality change is planned sufficiently in advance to allow the price to be readjusted at the same time. In such case, the right of (6) is augmented by the quantity $(p - r)(\partial n/\partial p)(\partial p/\partial q)$, and the right of (7) by this quantity plus $n\,\partial p/\partial q$. Since the price change $(\partial p/\partial p)\Delta q$ is at the publisher's disposal, it will often be possible for him to make the augmented forms of (6) and (7) simultaneously positive; this will always be possible if $(p - r)$ is sufficiently small. Thus a journal marketed at near its runoff cost can always modify its price in such a way as to benefit financially from a small quality change that is socially desirable, but adds to its prerun cost. Note that the truth of this statement is not altered by retention of the f terms in (6), as long as (6) and $\partial n/\partial q$ have the same sign. However, the statement need not remain true for a large quality change, since as q continues to increase the price will have to move farther and farther from r, and the supplemental terms with the factor $(p - r)$ may cause trouble.

The practical importance of the qualitative principles enunciated depends on how much opportunity publishers have to trade cost for quality and on the extent of the nonfinancial pressures that also influence their decisions. We discuss the latter pressures in Subsection 7, and merely cite here some empirical facts that seem to indicate that, in cases where the economic pressures may have been of antisocial sign, no particularly evil consequences have occured. The two major areas in which prerun expenditures can affect quality

are (a) typography and style and (b) technical quality; these correspond to the expenditures for composition and copy editing and for technical editing, respectively. As Section IIID showed, the journals produced by commercial publishers tend to have superior typography, but on the average their technical quality is considered by most users we have interviewed to be no better than and often below that of the society journals in the same field that are marketed at much lower prices. The typography can probably be interpreted as responding to the economic pressures described in the preceding paragraphs, but there are two reasons why the quality of technical editing is less affected by these pressures. One is that the society journals, for which the low price would in itself favor antisocial quality decisions, are precisely the ones for which the intellectual pressures from the scientific and technical community are most strongly favorable to quality. The other is that for journals that use part-time editors, as many do, the quality of editing and refereeing is not directly connected to the costs on the books; it is supported by the hidden subsidy provided by the editors' employers and determined by the strength of the editor's personal dedication to his task. It is quite possible that societies are better able to recruit dedicated editors than are commercial publishers.

4. Financial Motivations for Decisions: Role of Authors

So far we have concentrated on the way in which decisions are influenced by economic pressures from buyers. Authors of papers and sponsors of research and development can also make their judgments felt through economic channels. Sponsors make their views felt through

encouragement or discouragement of publication and through willingness or unwillingness to pay page charges; as these are largely matters of general policy rather than judgments about particular journals, we concentrate on the role of authors. Authors affect journals through their decisions on what to try to publish and, especially, through their choice of the journal in which to publish it. These decisions and choices reflect not only obvious self-interest but also the authors' view of a contribution to the f term in the value-Equation (1).

We have already briefly mentioned, in Subsection 3, the antisocial effect that a small group of authors can sometimes have on the "what journals" decision by encouraging a publisher to start a journal that is profitable to the publisher though a loss to society. An obvious point is that the <u>birth rate of undesirable expensive journals can be decreased if scientific and technical societies remain alert to possibilities for subdivision of their journals or initiation of new ones to meet changing needs</u>.

Let us now consider the reactions of authors to a managerial decision that affects the quality of a journal in such a way as to make it more desirable to authors as a place for publication. User demand will be affected by two factors: First, the quality of the journal may be improved (e.g., if the change is an improvement in the promptness of publication) or worsened (e.g., if the change is a lowering of refereeing standards); second, the bulk will be increased. As we have dealt in Subsection 3 with buyer response to quality changes at fixed bulk, we need consider here merely the economic changes due to the increased bulk, assuming the quality to remain constant. In this

we must bear in mind that the benefit to society as a whole resulting from a change in the size of a journal is entirely dependent on the comparison of this journal with the other journals with which it competes for papers and may be positive or negative.

Let us start with a rather crude model. We shall suppose that the number n of subscribers willing to pay a price p is a function of p/ν, where ν is the number of papers published, and that the prerun cost s and the runoff cost r per copy are proportional to ν. Actually, these assumptions, though convenient, are not always entirely realistic. Institutional subscribers, who should logically base their buying decisions on something like a p/ν ratio, often respond to changes with a tremendous hysteresis. Individual subscribers are often repelled by excessive bulk in any one journal. As for costs, Figure 11 suggests that the variation of r with ν will often be slower than simple proportionality. But the model described is of value as a transparent extreme case. For this model, it is not hard to see that an increase of ν will alter the subscription-income and production-cost curves of Figure 32 by expanding both the horizontal and vertical dimensions proportionally to ν. For a small increase in ν, a publisher operating near the "maximum-profit" point will have his profit increased. If the publisher operates, as many commercial publishers do, by offering subscriptions at a constant amount per page, with an unspecified number of pages in a year, or if the increase of ν is gradual enough for him to allow for it by an increase in his yearly price, his profit will increase as long as his operating point is to the right of the break-even point. Of course, if his price is not sufficiently above

the break-even point and if he cannot adjust his yearly price immediately, the increase in ν will momentarily increase his loss, or decrease his profit. (Transient effects due to sluggish readjustment of prices are really a part of the stability problem and will be discussed more fully in Subsection 5.) As far as long-range policies are concerned, however, our model illustrates a conclusion that probably remains valid even when one allows for the differences between the model and reality, since these act in different directions and tend to compensate one another: <u>High-profit journals are almost always economically motivated to increase their appeal to authors, regardless of whether society as a whole gains or loses by an increase in their bulk</u>.

Now let us consider publishers who operate at far from maximum profit. These always have the option of changing price so as to increase profit or decrease loss. But the very fact that a publisher chooses to forego maximum profit shows that he is basing his decisions on some sort of compromise between the welfare of his own finances and some other welfare, such as that of society as a whole. So the crucial question is, when will the hypothetical increase in volume ν of a particular journal, beneficial or harmful to society as a whole, be respectively desirable or undesirable from the point of view of its publisher's compromise? In two simple limiting cases the sign of the correspondence is obviously the proper one, at least if the social judgments of the publisher are sound: If the publisher operates at the break-even point, he is obviously choosing to maximize the net benefit to society under a rigid constraint of taking no loss,

and this policy will lead him to operate at the new break-even point when his volume changes and to prefer an increase or decrease of volume, whichever is the more desirable socially under the break-even constraint. Again, if the publisher sells his journal at runoff cost, he is evidently trying to maximize the net benefit to society regardless of how large a part of the production cost has to be supplied by his backers. In many intermediate cases, too, the same parallelism of the interests of society with the compromise value criterion of the publisher may obtain, again provided that the social judgments of the publisher are sound.

Unfortunately, the proviso just mentioned is not an easy one to satisfy, however noble the publishers' motives. If it were only a matter of assessing the value delivered to society through his one journal alone, it might not be too difficult a task to decide whether a change leading to an increase of bulk was socially desirable. But as we have stressed above, a more nearly correct assessment of the change in net value to society would subtract from Equation (3) a term describing the loss in value of the other journals from which the papers were shifted and add an f term describing the value of the improvement in speed or other quality of service. It will be difficult for the publisher to take these things adequately into account in his compromise criterion. Even if he is able to do so, it may sometimes happen that this criterion is adversely affected by a socially beneficial change or positively affected by a harmful change.

The foregoing discussion is based on the assumption that the publisher either has only the subscription income or augments this by

a subsidy from a society or other body that does not automatically increase when more papers are published. If he receives income from page charges, the situation is greatly improved. As far as the economics of the journal are concerned (as distinguished from net value to society), page charges that cover on the average a fraction λ of the prerun costs simply modify Figure 32 by replacing s by $(1-\lambda)s$. If λ is near unity, as it is likely to be for society journals, the break-even price is moved almost to the runoff cost r and, except for the transient fluctuations to be discussed in Subsection 5, the journal can adopt a policy of never operating at a loss without doing much violence to the social-welfare motivations of its sponsors. For example, suppose a journal is considering a technological change that, while increasing prerun costs, will greatly reduce the time interval between acceptance of papers and their appearance. It can cover much of the increased unit cost by increasing its page charge, and, if the improved service makes it more popular with authors, the proportional increase in page-charge income will offset the increased prerun cost due to the rise in bulk and will do so without the time delay that is required for institution of price changes. Thus the publisher will not be deterred from making the change by fear of financial loss. We conclude that <u>the use of page charges greatly reduces the likelihood that quality decisions by nonprofit publishers will be influenced in an antisocial direction by economic pressures arising from judgments of authors</u>.

With a for-profit publisher the beneficial effect of page charges on motivation is less clean-cut, though it may sometimes persist. Namely, receipt of page charges by a high-profit publisher,

even if these cover much less than the prerun cost, will augment the financial temptation, already noted above, for a publisher of this type to increase the appeal of his journal to authors without regard to social consequences.

There is one type of author judgment that has an especially noteworthy potential for social harm; this judgment involves the selection of a journal with or without page charges as the publication outlet for his work when money for payment of page charges must come from funds allocated for the conduct of his work. If all journals had equal page charges (or none), he would choose the one best fulfilling his needs, which might usually, though not always, be the one best serving society. Since this is far from the case, authors often are tempted for purely financial reasons to submit their work to journals that do not have page charges even though these journals are less desirable not only from society's standpoint but also from the standpoint of the author's own desiderata. The commonest type of case involves a high-circulation journal with page charges and a low-circulation journal without. Often the journal without page charges is a foreign journal, as we have seen in Section IIIA that there is as yet only a slight use of the page-charge system outside the United States. It is not usually realized in the scientific community that the flight to foreign journals may not even save any money for the community of U.S. research institutions. The reason for this last statement is that, while these institutions can save money in their research budgets by avoiding payment of page charges, the papers they submit to foreign journals will in the long run increase the annual subscription prices of these journals by increasing their

bulk, so that more money will be demanded from the budgets of their libraries. The latter loss will typically offset much of the former saving and sometimes may even outweigh it (see Attachment C for some typical numbers). Concomitantly, there is an adverse effect on the currently sensitive national balance of payments. We must also remember that there is apt to be an additional time delay (though perhaps small compared with the variations from journal to journal). Since society always pays for the prerun costs of journals in one way or another, we conclude that authors' choices of the journals to which they submit their work are likely to be socially deleterious if payment of page charges entails a significant financial loss for their work.

In much of the preceding discussion, we have been comparing the consequences, for various types of decisions, of economic pressures exerted by authors on journals with and without page charges. We also need to consider the effect of these author-generated pressures on decisions regarding the page charges themselves—whether to have them, how large they should be, and how to improve collection of them. The most obvious effects are (a) the economic pressure toward adequate page charges that arises from an increase in the bulk of material submitted and (b) the lessened attractiveness of page charges when a large proportion of the authors' institutions prove unable to honor them. Both these pressures are more apt to favor socially beneficial decisions than the reverse. The likelihood of socially deleterious decisions can be reduced by governmental and other policies that, on the one hand, encourage honoring of page charges and, on the other, impose standards

of performance on journals that receive page charges from government funds. (We discuss these matters further in Sections IVB.4 and IVC.1.)

5. Stability

So far we have considered only steady-state situations, but, as we have seen in the graphs of Section IIIB, circumstances change and often unpredictably. Nationwide economic fluctuations affect research and development funds; new discoveries or changes in technology cause some fields to grow and others to shrink; educational trends, the draft, and other factors affect scientific and technical manpower; supply-and-demand pressures, actions of organized labor, and the like affect production costs. So we must ask: What policies for the financing of journals will make them most able to respond to these changes in a smooth and orderly way, without wasteful crises and disruptions?

The fluctuations to which a journal may have to respond are those in:

Bulk. The amount of material submitted may change.

Demand. The number of subscribers may change.

Costs. Prerun or runoff costs may change.

We shall consider these in turn.

As we have briefly noted in Subsection 4, changes in bulk impose no great financial strain on a journal that sets a certain subscription price for a volume of fixed size, but allows the number of volumes per year to fluctuate, provided the journal operates at a profit, that is, to the right of the break-even point in Figure 32.

While the assumptions made there are somewhat idealized, departures from them probably do not alter the conclusion seriously: Greater bulk may increase economy because the runoff cost will increase a little less rapidly than the bulk, but at the same time decrease economy by forcing use of additional printers and the like. For this case, the yearly profit will fluctuate, but it is not likely to turn into a loss. If, on the other hand, the journal quotes a fixed price per year, it may take a year or more to adjust the price to an upward fluctuation in bulk. Such a fluctuation can cause a great deal of trouble if page charges are not used, unless the journal operates well to the right of the break-even point of Figure 32. Thus, under the simplified assumptions described in Subsection 4, expansion of the bulk v expands the vertical and horizontal dimensions of the curves of Figure 32 proportionally to v, and if the price is fixed, the profit will decrease. This can create a deficit for a self-supporting journal operating only slightly to the right of the break-even point and can dangerously increase the deficit of a journal (subsidized by some source other than page charges) operating to the left. We conclude that journals without page charges, and even some journals with page charges if these fall significantly short of meeting prerun costs, should as far as practicable quote subscription prices for volumes of fixed size rather than per year. Adoption of this policy is much less important for journals operating near the price of maximum profit; however, these usually have adopted it already.

Both fluctuations in bulk and fluctuations in demand perturb a journal much less if page charges are employed than if they are not.

We have just seen that, without page charges and with a fixed annual price, a rise in bulk can cause a financial crisis for a journal not operated well to the right of the break-even point in Figure 32. A decrease in number of subscribers can obviously do the same if the price is considerably above the runoff cost, as it normally must be for journals that do not impose page charges. On the other hand, in an ideal case in which page charges exactly cover prerun costs and subscriptions cover runoff, fluctuations in demand have little effect on the journal's economic balance, and fluctuations in bulk affect the balance only to the extent that they increase runoff costs. Although it is neither practical nor desirable for journals to operate under exactly these conditions, we can state the general principle, often enunciated in the past[4,37], that <u>economic stability in the presence of fluctuations in bulk and in demand is greatly favored by a page-charge system that provides coverage of a major part of prerun costs by a source of income proportional to the bulk published</u>. This fact is more important now than ever before, because of the threat to circulation posed by widespread use of copying techniques.

What about fluctuations in unit costs? Not much can be done about these, other than to find additonal income as quickly as possible. As we have noted, an annual subscription rate can be raised only with a rather long time lag. With a variable number of volumes per year, a comparable time lag may be necessary, but the maximum time lag will not be as great, since billing can be done at any time. A journal might also, as an emergency measure, decrease the size of the volumes supplied, thus forcing the subscriber immediately to pay more per unit of material;

this might entail some loss of good will. One type of income, however can be increased on very short notice: This is page-charge income. An increase (or decrease) in page charges can be announced and put into effect in only a few months. Of course, there may be limitations on how much of an increase in costs can be covered in this way. It is not appropriate to cover other than prerun costs with page charges; there is also a possibility (see Section IVB.4) that funding agencies may impose ceilings. Still, it seems safe to conclude that <u>stability in the face of cost fluctuations can be appreciably helped by a policy of supporting the bulk of prerun costs with page charges. It may also be helped by pricing subscriptions by the volume rather than by the year</u>. Both these policies, incidentally, decrease the danger of backlogs building up from financial causes.

Finally, dependence on advertising for a sizable part of the income of a journal obviously makes the financial position of the journal unstable with respect to fluctuations in circulation.

6. Underestimation of the Value by Buyers

In Subsection 3, and to some extent elsewhere, we have estimated the net value of a journal to society from the value judgments of its buyers, although we did include, as a reminder of the limitations of buyer judgment, an unspecified additional value term f in Equations (1) and (3). It is trivial to say that buyers are not infallible; the real question is, can we find any reliable ways of correcting or supplementing their judgments. Judgments of authors have already been discussed briefly in Subsection 4; they are surely no more reliable, and probably less important. Judgments of the

representatives of scientific societies, though also fallible, are apt to be better; we have discussed their role briefly in Subsection 4 and shall enlarge on it in Subsection 7. Here we would like to propose that the judgments of buyers be accepted as a roughly valid guide to the relative value of different journals, but that the dollar values obtained from the first term of Equation (1) be scaled up considerably.

We have cited in Section IIIC.2 several estimates of the amount of their current-awareness knowledge that scientists get from browsing through current issues of periodicals in their fields. We have also cited evidence that modes of communication other than primary journals, valuable though they are, fall far short of supplying a fully efficient alternative channel for the communication of information important to scientists in their work. Thus it is reasonable to conclude not only that science would be crippled without primary journals, but that availability of journals for browsing plays an important role in the progress of research. It is the latter fact, rather than the former, that is of most interest to us here. No one talks of abolishing journals altogether, and we could not make any comparison of the real loss to society if they were abolished (even were this known) with the buyers' estimate of the loss, because the buyers' estimate depends on the behavior of the high-price tail of curves such as those of Figure 31 which is not known. Our primary concern is the adequacy of the estimate of value increment corresponding to CEF in part (b) of Figure 31. This, though not unrelated to the total value, depends strongly on how much the real use of journals varies with their circulation. As we explained in Section IIIC.2, the several

operational-research studies we have attempted on this question have not yet given conclusive results, though we believe that with further work it should be possible to draw valid conclusions. So for the present we shall proceed on the fairly conservative premise that the price that a marginal-interest buyer is willing to pay correctly reflects an incremental value to the small group of users he represents and shall try to infer value to society from this.

If different users of information from the literature could be considered as independent noninteracting entities, the premise just described would amount to setting the f term in Equations (1) and (3) equal to zero. But users are not independent; they are a strongly interacting community. The studies cited in Section IIIC show that the leads that guide individual scientists to published information come in comparable degree from direct browsing or search of journals and from information supplied by colleagues (oral contacts, citations in papers and preprints, and the like), the latter being probably rather more important than the former. But the colleagues who mediate the latter type of information transfer receive their awareness, in turn, through the same sources; ultimately, if the chain of communication is pushed back to its source, this source will be the browsing or search of journals or, more rarely, direct communication from the author.

Thus a hypothetical increase or decrease in the ease of accessibility of a journal to large numbers of its users will affect the flow of useful information from it to a particular user in two ways: It will affect his direct use of the journal, and it will affect the availability of information in the population of colleagues with whom

he maintains contact. When he (or his buyer) sets a price he is willing to pay for an easily accessible copy of the journal, he is comparing his welfare with and without this copy, assuming the characteristics of his colleagues to be constant, independent of his decision. Actually, a change of price of the journal that will affect his decision whether to buy will also affect the decisions of a certain proportion of his colleagues, and so will affect the supply of information available to him through the indirect channels. Thus we conclude: <u>If decisions of buyers are fully enlightened, the value of a journal to society exceeds the sum of the prices all its buyers would be willing to pay for it by a sizable factor, representing the feedback effect of indirect communication</u>. If the different types of users all communicated equally well with one another, the f term in Equation (1) would be simply a multiple (probably a bit greater than one) of the first term.

It is illuminating to consider a mathematical model of the feedback effect just described, even though the model is necessarily oversimplified. Suppose a typical individual in a certain field spends in a year a time t_j in the use of journals and other published material in this field, a time t_g interacting with the "grapevine" of his colleagues, and a time t_s in acquiring new knowledge directly from the originators of this knowledge without the intermediary of publication. Then the net value to him of all these information-seeking activities can be expressed in terms of an equivalent amount T of his time, thus:

$$\text{value} \propto T = J(t_j,q_j) - t_j + G(t_g,q_g) - t_g + S(t_s) - t_s, \quad (8)$$

where q_j, q_g, are parameters describing the characteristics, respectively, of journals and books, and of the population of colleagues with which the individual interacts, and J, B, and S are some functions of their arguments. With t_j, t_g, and t_s at the disposal of the individual, he will naturally choose them to maximize T, that is, to satisfy

$$\frac{\partial J}{\partial t_j} = \frac{\partial G}{\partial t_g} = \frac{\partial S}{\partial t_s} = 1 \ . \tag{9}$$

What we are interested in is the change of T when a small change is made in the q_j, assuming Equation (9) is satisfied. Thanks to Equation (9), as far as effects of the first order in the magnitude of a change Δq_j in q_j are concerned, there is no change in T due to the concomitant changes in t_j and t_g. But in general a change Δq_j will change the q_g, since the individual's colleagues also rely to some extent on journals and books. Thus we must evaluate

$$\Delta T = \frac{\partial J}{\partial q_j} \Delta q_j + \frac{\partial G}{\partial q_g} \Delta q_g \ . \tag{10}$$

If the colleagues of our individual have on the average the same information-gathering characteristics that he has, the relevant parameter q_g can be taken to be a quantity proportional to the total value of information received by this typical individual per unit of time, that is,

$$q_g \propto J + G + S \tag{11}$$

$$\Delta q_g \propto \Delta J + \Delta G + \Delta S = \Delta T. \tag{12}$$

It is plausible to take G as simply proportional to this q_g, so that we can insert into Equation (10) the relations $\partial G/\partial q_g = G/q_g$. Then Equation (10) becomes

$$\Delta T = \frac{\partial J}{\partial q_j} \Delta q_j + \left(\frac{G}{J+G+S}\right) \Delta T,$$

whose solution is

$$\Delta T = \frac{\partial J}{\partial q_j} \Delta q_j \left(\frac{J+G+S}{J+S}\right) . \qquad (13)$$

The factor in front of the parentheses in Equation (13) is the value ΔT would have if the change in the journals—insofar as it affects the individual in question—could be made without affecting his colleagues. For example, suppose q_j is the circulation of a journal, which will be lowered by Δq_j if this individual and all others like him decide to stop subscribing. The the factor $(\partial J/\partial q_j)\Delta q_j$ is what the individual will weigh against the subscription cost (plus storage costs, etc.) in deciding whether he should subscribe. The quantity in parentheses in Equation (13) is the amplification factor, by which the individual's value judgment should be multiplied to get the social impact of a decision by the publisher to raise the subscription price and thus lower circulation. As S is in most cases $\ll$ J or G, the amplification factor is nearly (J+G)/J, which according to Section IIIC.2 and Figure 26 is typically of the order of two.

Note that we have lumped all published sources of information into the J term. For pure scientists, as Figure 26 shows, this term is dominated by the use of primary journals, either browsing or searching with the aid of abstract journals. For engineers, however, it is

dominated by handbooks, specifications, catalogs, and the like[45]. The characteristics of this latter kind of material ("books" for short) are probably much less sensitive to the parameters q_j than are the characteristics q_g of the population of colleagues. If we ignore the dependence of the "books" on the journals, thereby slightly underestimating the amplification factor, we can use Equation (13) for the world of engineering with the interpretation that J refers to journals plus "books." This leads to the conclusion that, although the value assigned to journals by engineers is considerably less than that assigned to them by scientists, the amplification factor is somewhat greater in engineering, because the G term is relatively larger[45].

7. Noneconomic Motivations

As we have mentioned, the management decisions made by publishers of journals are often motivated by noneconomic as well as by economic considerations. While noneconomic motives are strongest for journals published by scientific and technical societies, even commercial publishers can have motives that are not purely economic, at least in the immediate sense. Omitting the always laudable though rarely dominant concern for the welfare of science and technology as a whole, and the always deplorable though often dominant trait of laziness, we can name at least two intermediate motivations that are often important:

Prestige of the journal or its publisher. Insofar as this enhances the market for the journal, it is an economic motivation, but many societies and other publishers attach an additional value to it. Publishers motivated by this extra desire for prestige are apt to seek a higher circulation than they would for purely economic reasons, and

this will generally be socially desirable. They may also raise refereeing and other editorial standards, and this is more likely to be socially desirable than not, since we have seen in Section IIIC.1 that the value of users' time is many times current production costs. However, there always will be a point of diminishing returns.

Welfare of a particular professional group. Professional societies often have more concern for the interests of their members, both as authors and as users of published material, than for the rest of the scientific and technical community. This is manifested in low subscription rates for members, and occasionally in the imposition of page charges only on nonmembers. More often than not, however, the interests of the members of a society run parallel to the interests of science and technology as a whole, so far as they touch on a journal published by this society.

It is to these noneconomic motivations that we must give principal credit for the fact, of which we are convinced from conversations with our colleagues, that on the average the large society-published journals are of higher quality and provide better service than those of private publishers (though, of course, many of the latter play a very useful role). The important point for us here is our conviction—though it is difficult to establish quantitatively—that the noneconomic motives of those who manage society-published journals have as much effect on their managerial decisions as economic pressures, and this effect is preponderantly toward socially desirable decisions. Thus, economic pressures in an antisocial direction, when they occur, will often be mitigated or overruled by the noneconomic forces.

Of all the types of decisions enumerated in Subsection 2 above, the one that most needs to be based on noneconomic motivations if it is to favor the welfare of society is that of "what journals"; that is, when should a new journal be started or an old one discontinued. We have seen in Subsection 3 that an undesirable journal can often be made to yield a profit and can almost never be forced out of existence by user apathy. The major reason is that if the existence of journal A detracts from the social utility of Journal B—for example, by transfer to A of papers that would otherwise appear in B—the loss of utility of B does not appear as a debit in the finances of A. Only if A and B are issued by the same publisher will economic considerations deter the publisher of A from starting or continuing his journal. When the publisher is a scientific or technical society, consideration for the total welfare of the membership can have a very salutary effect. But even here, if the membership of the society is only a small fraction of those affected by the journal, their special interests may not coincide with those of society as a whole. This sometimes happens, for example, with journals published by academies of science of very small countries.

B. Conclusions Regarding Alternative Roles for Government

In line with the philosophy we developed in Section II, we would like to find broad policies for support of journals that will provide the maximum encouragement for socially beneficial consequences to result from the myriads of decisions that are made by users, buyers, authors, and organizations of scientists and technologists. In Section IVA, we have made a number of points (underlined passages) that should be considered carefully by any group that undertakes the formulation of such

broad policies; in particular, we commend them to scientific and technical societies and to government agencies, universities, and other bodies that support research in the public interest. Unfortunately, it is difficult to devise any feasible policy that will fully meet all the desiderata we have developed. While the ideally wise and benevolent dictator hypothesized in Section II might be able to distribute funds to journals, authors, libraries, and the like in a way that would meet all the desiderata, feasible policies for the real world are subject to a number of constraints. Therefore, we must seek compromises. Let us consider governmental policies first. For these, two important constraints are:

Simplicity. A policy should be clear-cut and simple to administer; it should not burden administrators with difficult and touchy decisions, nor be susceptible to widely different interpretations on the part of different administrators; it should not require detailed processing of myriads of individual cases.

Compatibility. Any policy on journal support should be compatible with existing rules or policies of wider application (e.g., postal regulations) and with present fiscal procedures of governmental agencies.

While neither of these is a fully rigid constraint, both are real. We must consider them as well as the points developed in the various subsections of IVA as we weigh four possible types of policies on government support for journals:

(i) No support

(ii) Support through buyers

(iii) Support given directly to journals

(iv) Support through authors

(Here, and throughout our study, we deal only with primary journals as described at the beginning of Section III. While many of the principles we have developed in IVA apply also to review literature, there are quantitative and even qualitative differences between the economics of these two types of publication.)

1. The Alternative of No Support

A no-support policy would superficially satisfy the constraints of simplicity and compatibility, but how would it affect journals and their use? Although page charges originally were introduced at a time when very little of the nation's research and development work was government supported, they are much larger now than they were then (see Section IIIB.3) and there seems to be no doubt that a cessation of government support of page charges for publication of sponsored work would result in a marked decline in the page-charge income of journals (see Figures 12 and 16, Figure 17, and the discussion in Sections IIIA.6 and IIIB.3) and might force many journals to abandon page charges altogether. This lost income could be replaced by raising subscription rates, of course, though the shock of the transition might do much damage unless it were very smoothly carried out. Presumably the (nonprofit) publishers that now rely on page charges would in most cases raise their prices to the break-even point in Figure 32. Of more lasting concern, however, are the effects such a policy would have on the value received by periodical users and on the economic stability of journals. According to Section IVA.1, the judgments of buyers are most effective in maximizing the net value of a journal to society when its price equals its runoff cost. As the roughly realistic

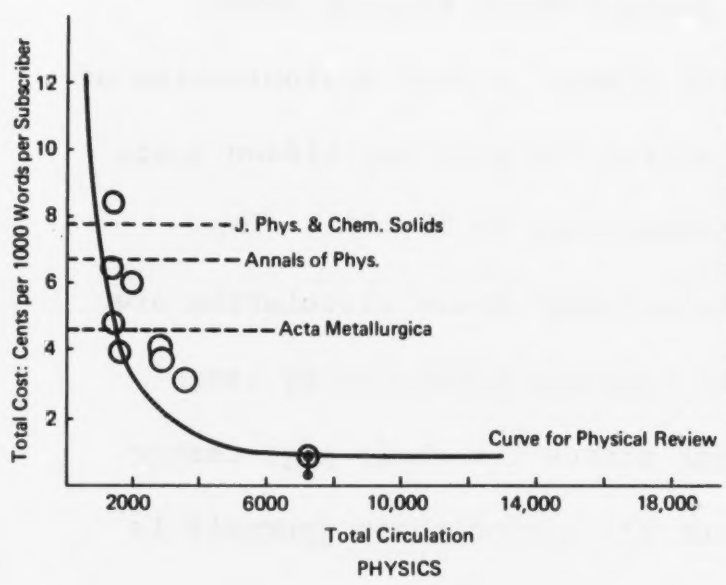
Figure 32 shows, the circulation (hence the use) of a journal at the break-even point is apt to be significantly less than when it is marketed at runoff cost, and, as we indicated in Section IVA.1, this entails a loss in value to users that exceeds the saving resulting from the production of fewer journals, the difference being the triangular area CEF in Figure 31(b).

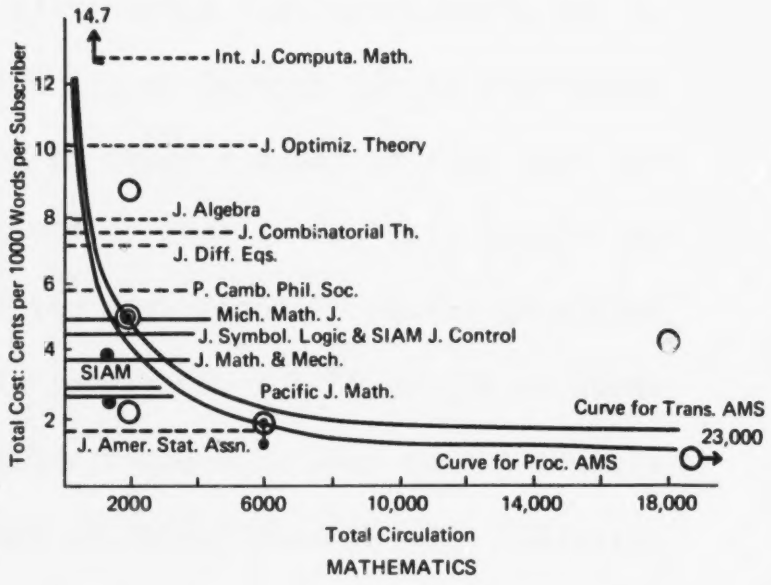
Stability with respect to short-term fluctuations in bulk, demand, and costs, as we found in Section IVA.5, is much greater if there are two sources of income, proportional, respectively, to bulk and to circulation (or circulation x bulk), than if all income is of the latter type. To balance those considerations, there is only the argument that a no-support policy might favor better management decisions by journal publishers. We have argued in Sections IVA.3 and IVA.4 that subsidy and low price can influence such decisions either favorably or unfavorably, depending on various circumstances; in some cases they exert little or no influence. What we need is a roughly quantitative assessment of the net importance of all such influence and of the circulation-and-use factor mentioned earlier.

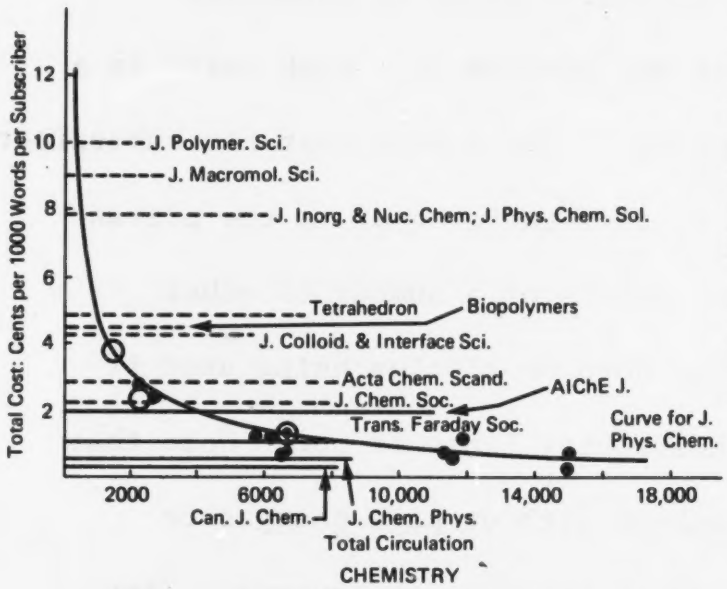
Many proponents of the no-support philosophy believe that journals supported by page charges lose their motivation for effeciency and become wasteful, maintaining their low subscription rates only by virtue of exorbitant page charges. Although both the data reported in Section IIIA.4 and the theoretical reasoning of Subsections IVA.3 and IVA.7 suggest that this suspicion is usually unfounded, an analysis of cost and price data can make the true state of affairs even clearer. From the data on prerun and runoff costs collected for Section IIIA.4,

we can compute not only the total production costs for certain society journals but the way in which the total production costs would change if the circulation were arbitrarily changed while keeping other properties of the journal (e.g., bulk) fixed: A fair approximation of the cost will be the s + rn(p) of Equation (2) plus any hidden cost; the latter will cancel most of the comparisons to be made. The resulting curves of total cost per subscriber versus circulation are shown in Figure 35 for several of the journals published by large societies that have come under violent attack for their page-charge policies. The present operating point of each of these journals is shown by a circled black dot, and its present price to nonmember subscribers is shown as a plain black dot beneath it. Each curve is a hyperbola, the height of whose asymptote is the runoff cost per subscriber and which rises above its asymptote by a distance equal to the prerun cost per subscriber. For comparison, prices of a number of other journals are shown on the same graphs, dots or circles being used if the circulations were known to us, horizontal lines if not. Note that journals of private publishers and others without page charges or direct governmental subsidy usually lie well above the curves. (For journals of unknown circulation, of course, all that can be said is that they could not lie below the curves unless their circulation were improbably small.) Thus the total cost paid by society as a whole for the production of the unsubsidized journals is distinctly more than the total cost would be to produce the journals for which the curves are drawn, if the latter were produced in equal numbers.

Although these data are for a few selected cases only and do not preclude the possibility that some journals with page charges are







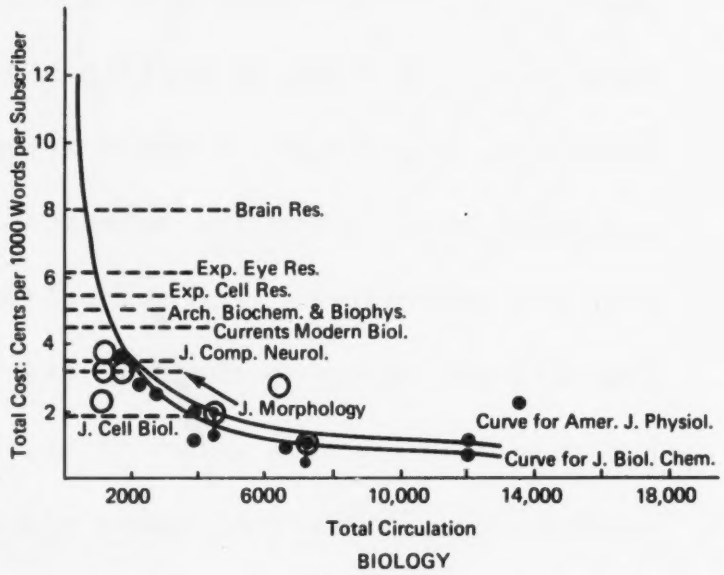


FIGURE 35 Comparison of prices charged for journals in certain fields with computed curves showing the circulation dependence of the total cost of producing one or more specific large society journals in each field. The double circle shows the actual total production cost and actual circulation of the journal for which the curve is drawn; the point connected to it by a vertical line is the actual price at which this journal is sold to U.S. institutions (usually about twice the price to society members). Other points show institutional prices of other journals in the same field for which we could obtain circulation figures, filled circles being used for journals with page charges or direct company or government subsidy, open circles for all others. Typical journals whose circulations are unknown to us are shown by horizontal lines, continuous if they have a page charge or subsidy, dashed if not. The computed curves would be more accurate if the abscissa were total runoff (including stock for back numbers) rather than circulation, but the necessary data were not usually available.

inefficiently produced, we believe the picture to be basically correct for most of the large journals of major societies and that, by all present standards, these journals are quite efficiently produced. While publisher's profits, of course, are included in the plotted prices, they are a part of the cost of the journal to society, and the fact that private publishers do not market journals below the total cost curves is an indication that the private publishers' costs are at least not markedly below those of the societies; note also that some of the non-page-charge journals are nonprofit.

The prerun cost figures collected in a recent George Washington University study[17] suggest a similar conclusion. Figures on prerun cost per page were obtained from some 80 journals. Unfortunately, these were not normalized to take account of page size; moreover, some of the figures were rather ridiculous, for example, 50 cents or 239 dollars. However, in every field the average prerun cost per page was less for journals with page charges than for those without them.

The evidence suggests that any improvement in the operation of journals that might result from the different outlook under a no-support policy would be slight, at best, and that it might be offset, or more than offset, by some of the antisocial economic pressures that theoretically can arise under such a policy (as mentioned in Sections IVA.3 and IVA.4). Now let us consider the loss in value of a journal to its users due to the decreased circulation resulting from the higher price under such a policy, a plausible estimate of which is about twice the area CEF in Figure 31(b). A study of Figures 7 and 35, with allowance for the fact that many present subscriptions go to

individuals at a reduced rate, suggests that, for a journal such as the Physical Review, the loss in net value to society due to replacing the present price by the break-even point could well be several hundred thousand dollars, a sizable, though minor, fraction of the total publication cost. When this loss, which according to Section IVA.6 is apt to be an underestimate, is combined with the fact that operation of a journal near the break-even point is economically unstable (Section IVA.5), one can hardly escape the conclusion that in a society in which a major part of the research is supported by the government, it is socially unwise for the government not to support publication of this research. Thus we reject a no-support policy.

As an addendum to these arguments, it is worth noting that journals supported entirely by subscriptions are apt to be so expensive that the developing countries cannot provide their institutions with an adequate supply of them.

2. Support through Buyers

The argument for governmental subsidy of the buyers of journals is that it would increase circulations in such a way as to place in the hands of the buyers the judgments regarding how the support should be divided among the various existing journals, including those of commercial publishers. An obvious disadvantage of this type of support is the difficulty of reconciling it with the simplicity and compatibility constraints mentioned at the start of Section IVB. It is difficult to identify all the potential buyers who should be supported and to deal with all types of them. Moreover, as we shall show, it is difficult to devise a formula for buyer support

that will encourage socially desirable subscriptions without stimulating socially undesirable ones, or one that will help the socially desirable uses of commercial journals without increasing the temptations and opportunities for profiteering.

Many buyers of journals, both individuals and organizations, are effectively subsidized by the tax laws; they can deduct journal subscription costs from their taxable income, or they are tax-exempt organizations. But this type of support does not single out journals in preference to other tools of research or development. The buyer makes his decision whether to subscribe on the basis of an unbiased comparison of the benefit he expects to receive from a journal with the benefit the same amount of money could give him if used for some other research or development purpose. The type of support we wish to discuss is different: Its goal is to fill the gap between the total production cost of a journal, including publisher's profit, if any, and the runoff cost, which as we have shown in Sections IVA.1 and IVA.6 is an upper bound to the amount of money that buyers should be asked to divert from other uses in order for it to be socially desirable to supply them with the journal.

The economics of support through buyers can be analyzed by again using plots of publisher's income and cost against price, analogous to Figures 32 and 33. Figure 36 shows the same income and expense curves as Figure 32, and, as an example, the way these would be modified if the government provided all buyers with a subsidy equal to a fraction Δ of the price p paid to the publisher. The effect of this subsidy is to change the number n(p) of subscribers at price p to

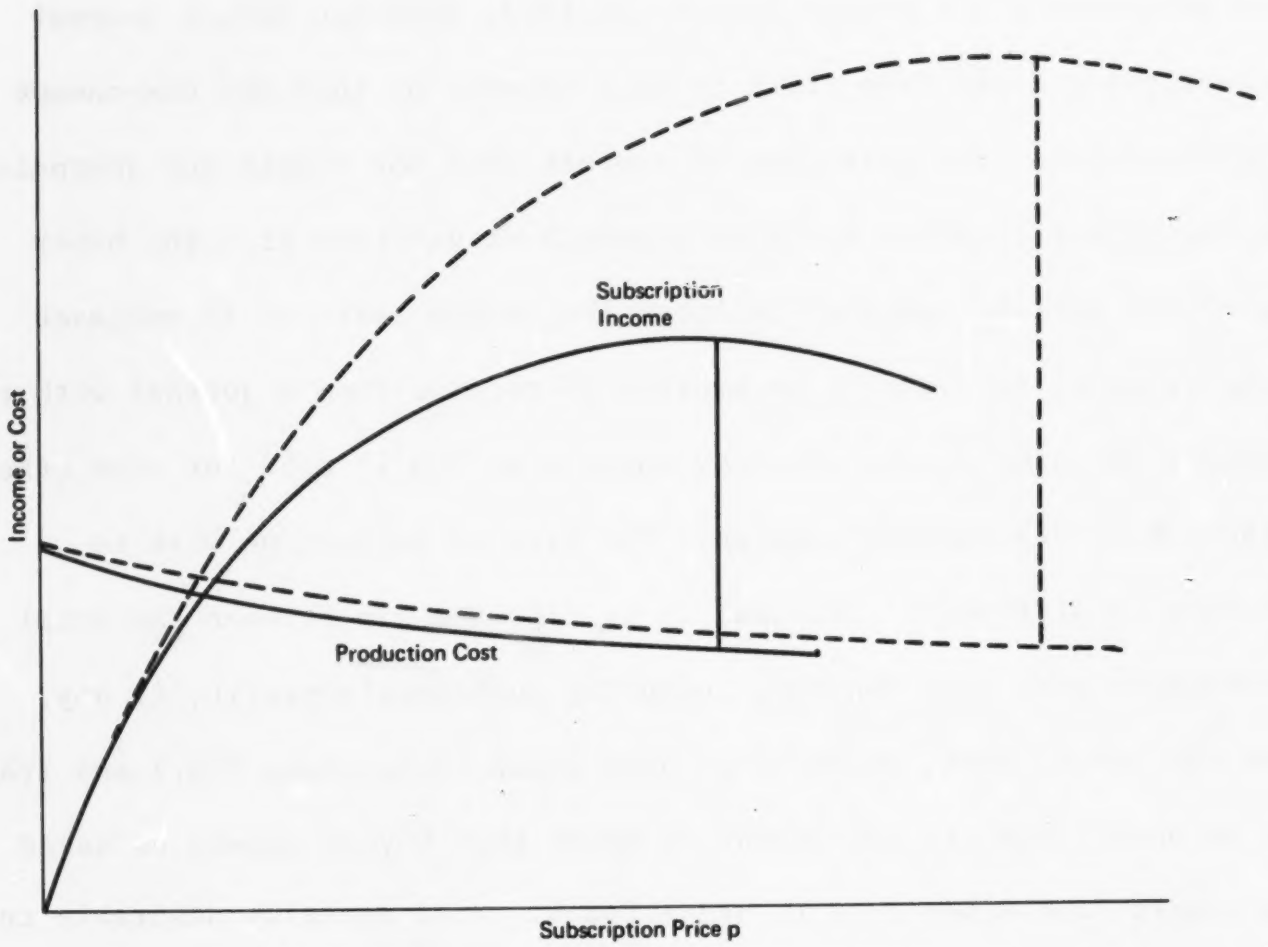


FIGURE 36 Effect of subsidizing buyers on the economic balance of a journal. The full curves show the dependence of total production cost and subscription income, respectively, on price p, in the absence of a subsidy; the dashed curves are those that apply if each buyer is required to contribute only $(1 - \Delta)p$ to the purchase of the journal, Δp being contributed by a subsidy. The vertical lines show the maximum profit the publisher can make.

a new function equal to $n[p(1-\Delta)]$. The change this produces in the production-cost curve is a simple horizontal stretch: The abscissa of each point is increased by the factor $(1-\Delta)^{-1}$: As many will now be sold (hence must be produced) at price $p(1-\Delta)$ as were originally sold at price p. The change the subsidy produces in the curve of subscription income is an expansion by $(1-\Delta)^{-1}$ in both the horizontal and vertical directions.

Since the point of maximum profit occurs only very slightly to the right of the maximum in the subscription-income curve, a subsidy of this sort will increase the price yielding maximum profit by almost $(1-\Delta)^{-1}$; therefore, it will bring about very little increase in the circulation of a journal operated at maximum profit. The publisher's profit will be increased by rather more than the factor $(1-\Delta)^{-1}$, since the height of the maximum in the subscription-income curve will go up by this factor, while the height of the cost curve at the maximum-profit point will be changed very little. While one could imagine forms of buyer subsidy other than a simple fraction of subscription expenditures, their effect will always amount to some sort of (possibly nonuniform) horizontal stretching of the n(p) curve, and the qualitative effect on cost, profit, and social value will usually be similar to that in the example just discussed. Thus <u>it is difficult to arrange a subsidy of buyers that in an otherwise free market will ensure significantly larger circulations for journals produced for profit</u>.

Thus far we have been tacitly supposing that the subsidy given to the buyers increases if they elect to spend more on journals. A subsidy almost has to be of this sort if it is to be effective. If the

buyers are given a lump sum, not dependent on how much they spend for journals, their decisions on which journals to buy will not be affected at all, unless, of course, the subsidy—which presumably must be spent for journals—exceeds the total that they would otherwise spend for them. Even in this latter case of a very large subsidy, the effect on any single journal will be similar to that discussed in the preceding paragraph.

What about the effect of buyer subsidies on nonprofit journals? It will suffice to consider a journal operated at the break-even point where production cost and subscription income are equal. Since introducing a subsidy modifies the amounts of money buyers contribute from their own pockets, the enhancement of circulation resulting from a subsidy totaling D dollars is not simply D/r, where r is the runoff cost per subscription; it is normally somewhat less. However, calculations for typical cases show that the effect of the subsidy on circulation will usually be roughly (though not exactly) the same as if the same number of subsidy dollars had been used to support prerun costs, for example, by page charges. We conclude that for nonprofit journals the steady-state economic effects of a buyer subsidy would be beneficial and a reasonably efficient use of the funds involved. But the stability of operations achievable under the page-charge system (Section IVA.5) could not be realized.

A buyer subsidy of the type we are considering can obviously induce some buyers to subscribe even when they assess the value of the journal to them at less than the runoff cost. Such decisions can be unprofitable for society as a whole, if the simple criterion of

Section IVA.1 is used. However, the social loss can be lessened or reversed by the cooperative effect discussed in Section IVA.6. Moreover, with a price-circulation relation like that of Figure 7 and runoff costs like those of Figure 11, the loss, if any, will be negligibly small.

At the beginning of this discussion of subsidy of buyers, we mentioned that it is administratively difficult to identify and deal with all the buyers who merit support. This conclusion follows from a look at the circulation statistics of typical journals. As we noted in Section IIIA.2 and Figure 5b, comparable fractions of the circulations of typical society journals fall to individual members and to "nonmembers," usually libraries. It would be difficult for the various government agencies supporting research to deal with all the individual subscribers, and practically impossible politically to effect the desired subsidies by modification of the income-tax laws. Even identifying libraries for subsidy purposes would be very difficult. For example, the Physical Review in 1968 had over 2000 U.S. "nonmember" subscribers, the American Journal of Physiology about the same, and the Journal of the American Chemical Society considerably more. Comparable numbers of these subscriptions go to educational and to commercial institutions; other types of institutions also subscribe. The large institutions, even with multiple subscriptions, account for only a minor fraction of the institutional subscriptions. Handling and monitoring the journal purchasing activities of the myriads of small institutions, especially the commercial ones, would be exceedingly difficult. Yet it is just the marginal-interest buyers that are most

in need of support: They are the ones that will drop out if the price is high, and their doing so can result, as we showed in Subsection 1, in an appreciable economic loss to society.

One more disadvantage of relying on buyer subsidies deserves to be mentioned. Difficult as it would be, politically and administratively, to set up a framework for subsidy of buyers within the United States, it would be enormously more difficult to provide such a subsidy to foreign purchasers of U.S. journals. These purchasers would have to pay higher prices than now for those U.S. nonprofit journals currently using the page-charge system and might well have to pay higher prices for commercial journals, as the prices of the latter might go up. International communication would suffer from the resulting cutback in subscriptions, and the blow would be especially harmful to science and technology in the developing countries.

In summary, our feeling is that subsidy of journals by monies paid to buyers, to be used for subscriptions, would be prohibitively difficult to administer and even under ideal conditions would not be very satisfactory: It could not easily be made to improve the net benefit to society from commercial journals and, although it could enable nonprofit journals to increase their social usefulness, it would not help their stability in the way that page-charge support does.

3. Support Given Directly to Journals

Once the desirability of a governmental contribution to the cost of publishing journals is admitted, it seems logical to ask why this contribution should not be paid to the journals directly, instead of going through the hands of authors or buyers. For example,

one might designate some central agency to receive publication allotments from all governmental agencies that sponsor publishable work and to disburse page-charge payments to all qualifying journals that publish such work. Detailed arguments in favor of this scheme have been given in Reference 8. Even more direct forms of subsidy could be envisioned. One could easily incorporate any desired mix of contributions aimed at prerun or at runoff costs, although the whole import of the arguments we have given previously is that the type of subsidy of most social usefulness is normally one that supports just prerun costs.

Direct support also has disadvantages, as compared with support through authors via page charges. Under the page-charge system, industrial and other sponsors of research and development who are able to pay can contribute to the support of prerun publication costs on the same basis as governmental sponsors. If the latter made their contributions in a different way, it would be necessary either to retain page charges for the former while waiving them for the latter or else to abandon page charges altogether and count on the subsidies to replace them. The first of these policies, though perfectly possible, would not in itself get rid of some of the most criticized aspects of the page-charge system, such as the embarrassment of impecunious research workers. The second would require substantially larger disbursements by government agencies than at present to support the same fraction of journal costs, since the page-charge contributions of many industrial and other institutions would disappear. While this higher level of governmental support might well be socially justifiable,

it would augment the danger of catastrophic fluctuations in support, a danger that is the subject of the following paragraph.

Perhaps the most troubling aspect of direct governmental subsidy of journals arises from the centralization that it would probably entail. If the funds earmarked for journals were separated from the general research and development funds and appeared as a separate major item in an agency's budget, their level would be very susceptible to fluctuations imposed by higher level officials or Congressional committees; these people would be less likely to take a balanced view of the role of publication than do the working-level program officers of the agencies. The danger would become worse if, in the interest of efficiency and uniformity, subsidy of journals were made the responsibility of a single agency of the government, rather than being distributed among many. It might even be contended in some quarters that government-supported publication of government-supported work should be performed by the Government Printing Office. In general, we feel that the budgeting of reasonable amounts for the support of journal publication is best entrusted to the pluralistic judgment of numbers of administrators closely involved with the support of research and development and in contact with the scientists and engineers who do such work. These administrators should be constrained only by their overall research and development budgets and by broad guidelines enunciated by the highest policy-makers, coordinated through the Federal Council for Science and Technology.

We feel that the disadvantages mentioned in the last two paragraphs outweigh any possible advantages.

4. Support through Authors

The present page-charge system provides this type of support. The pattern of government support authorized by the 1961 statement of the Federal Council satisfies the constraints of simplicity and compatibility fairly well. However, this pattern has some defects, though on the whole it has worked successfully; the difficulty is to find modifications of the present policy that will remedy these defects and still satisfy the constraints. In the following paragraphs, we discuss, in turn, a number of aspects of page-charge financing: the benefits it offers, sources of funds for payments, the troubles that may develop, a variety of measures for dealing with these, and some suggestions for the more distant future.

Benefits from page-charge or other prerun support. Three great benefits can be realized if there is, from some source or other, a contribution to the income of journals that is proportional to the amount of material published and of the same order as the prerun cost. A contribution of this type makes possible marketing at near runoff cost, with resulting improvement in the benefit received by society through marginal buyers (as discussed in Section IVA.1). The low market price is additionally a boon to scientists in developing countries. Nonsubscription support of prerun costs also enhances the stability of journals in response to short-term fluctuations in bulk, demand, and costs (as discussed in Section IVA.5). Stability with respect to reprographic and microform copying and the possibility of adjusting page-charge levies on short notice in response to changing conditions are further advantages. A third benefit is the latitude that such

financing gives to publishers to experiment with new user-oriented services, such as the proposal of the American Institute of Physics discussed in Section IIID.7.

All these benefits are optimized when the nonsubscription contribution to the income covers only the prerun costs. As we have discussed in Sections IVA.3 and IVA.4, there are a number of ways in which the level of this contribution can affect the degree of parallelism between the economic interests of the publisher and the interests of society as a whole; in our judgment, the net import of the underlined passages in these subsections is that this parallelism is usually best favored if the nonsubscription contribution to the income is slightly less than the full prerun cost. While this conclusion is subject to some uncertainty—we have even, in our discussion of the no-support policy above, entertained the possibility that it might be entirely wrong—we believe it to be as good a guess as one can make at present. If we accept it, then there is no serious conflict between the "parallelism" desideratum and the three benefits mentioned in the preceding paragraph, since under present conditions (see Figures 7 and 11) the runoff cost is usually a small fraction of the cost at which the number of subscribers is halved. We conclude that <u>from the standpoint of society as a whole, the optimum type of support is one that covers most, but less than all, of the prerun costs and that makes possible a subscription price at which the number of subscribers is only a little below the number that would buy at the runoff price</u>.

<u>Sources of funds for page charges</u>. Having reached this conclusion, we must still ask how much of the "support," that is,

nonsubscription income, should be sought from nongovernmental sources, how much from government, and how it should be channelled. Usually, such support has been justified on the basis that research is not useful until it is published; therefore, those who sponsor research should allocate at least enough support toward publication of such work to get the first copy into print. This is a reasonable view for any organization that sponsors research in the public interest; as far as the federal government is concerned, this view was endorsed by the Federal Council for Science and Technology in its 1961 statement[5] and reiterated in 1968. Industrial research organizations, which might seem to be the ones least likely to adopt this public-interest point of view, seem in many cases to have accepted the obligation to pay page charges, though in other cases they have balked. Their attitude in the favorable cases is not necessarily altruistic; it is probably strongly affected by the value they get in prestige, priority, and the morale of their employees. The high evaluation of these factors, especially prestige, is illustrated by the comparatively enormous investment of editorial time some of the largest industrial laboratories are willing to make in order to produce high-quality journals in which to publish their work (see Figure 10). Thus reluctance to pay page charges, or otherwise to support setup costs, occurs primarily for only two classes of sponsors of research, and for these more from economic necessity than anything else: These are foreign institutions that may lack foreign exchange and domestic universities or nonprofit organizations that often are more concerned about their financial problems of the moment than about inconspicuous long-range contributions to the national welfare.

The question, therefore, is: Can a scheme be devised that will let government and industry support prerun costs for publication of the research they sponsor, without any unfavorable effects on publication of work sponsored by the other groups just mentioned? The usual policy of journals using the page-charge system has been to waive page charges for the work of these other groups, if there is reluctance to pay, and to use subscription income, society dues, or other income to support the corresponding prerun costs. Such a policy is reasonably consistent with the support desideratum we have formulated, provided that the articles for which page charges must be waived constitute only a minor fraction of the total work published. According to the evidence we have summarized in Figure 17 (Section IIIA.6), a majority of the articles published in U.S. journals of nearly all fields report work done either with support from agencies of the U.S. government or at industrial institutions; in many fields this majority exceeds three fourths. Thus, in the great majority of cases the amount of prerun support we have recommended in the immediately preceding underlined passage could be obtained if all government-sponsored and most industrial work honored a page charge set at about the actual prerun cost for each paper and if page charges were waived for most other work.

Possible troubles. In effect, we endorse the system of page-charge financing currently used by many of the large society journals. But we must give thought to the following possible troubles that can occur with this system:

(i) The temptation of authors to submit their papers to what would otherwise be less desirable journals to avoid the page charges of the

more desirable ones. (We have commented on this in Subsection 4.) Three cases can be distinguished:

(^{i}a) Authors with government support who wish to gain more money for their other needs.

(^{i}b) Authors, similarly motivated without government support but still reasonably able to pay.

(^{i}c) Authors whose institutions are unable to pay, who shun the embarrassment of admitting this.

(ii) Possible economic strain on journals faced with an excessive fraction of papers not honoring page charges. (Under the 1961 Federal Council policy[5], use of contract funds for page charges is authorized only if payment is not mandatory.) It is appropriate to distinguish two possible causes:

(^{ii}a) For some reason a particular journal may be deluged with an abnormally large number of papers from foreign or impecunious institutions.

(^{ii}b) If it is made too clear that authors' institutions have no obligation to pay page charges, some institutions that otherwise could easily be persuaded to pay, as a public service, may not do so.

All these difficulties are apt to vary greatly in importance from journal to journal and from time to time. As they have to be resolved by judicious compromises, it seems best to adopt general policies that will encourage journals to use as much initiative as possible in dealing with them, subject only to very broad restrictions. At the same time, it is desirable to let the authors retain some economic interest in seeing to it that the page-charge monies

placed at their disposal are used wisely; we wish to constrain them only as far as is necessary to mitigate the difficulties mentioned above.

Earmarking of publication funds. The solution to difficulty (^{i}a) is obvious: If government support of publication is to be through authors, all research and development contracts should budget plausible amounts for anticipated expenses of publication, and these amounts should not be transferrable to other uses without approval of the responsible program officer. The first part of this recommendation is already often reasonably well followed: For example, in most fields the research grants of the National Science Foundation and the Atomic Energy Commission budget an average of 300 dollars to 500 dollars per faculty man-year for publication expenses; this figure is more constant from field to field than is the ratio of publication allotment to total grant. Only about ten percent to 20 percent of applicants fail to include a publication item in their budgets. Rules restricting the freedom to reallocate this item will have to be formulated judiciously to avoid conflict with our constraint of "simplicity," especially for small grants, for which actual publication costs may fluctuate widely on either side of estimates and the cost of processing applications for supplemental funds is apt to be of the same order as the sums applied for. In such cases, program administrators might encourage somewhat more liberal budgeting for publications than for larger grants or contracts.

Although our primary concern is with the use of governmental funds for page charges, it is worth noting that philanthropic organizations

can also arrange the terms of their grants to research workers so as to avoid difficulties (^{i}b) and (^{ii}b). An example is provided by the Petroleum Research Fund of the American Chemical Society that pays page charges without including them in the grant.

The two-track system. If difficulty (^{ii}a) occurs only sporadically, (^{ii}a), (^{ii}b), and to some extent (^{i}c) can all be dealt with quite efficiently by the two-track system: A journal budgets a reasonable percentage of its non-page-charge income to support prerun costs of papers that do not pay the page charge. The total volume of such papers published in each issue is not allowed to exceed the volume that this budgeted sum will support; papers honoring the page charge, on the other hand, are published as fast as they are received. If the nonhonoring papers received in some brief period exceed the number that can be published under the budget, a backlog will accumulate, the publicized existence of which will tend to divert further authors in this category away from the journal in question or stimulate them to find funds to pay page charges. Even the threat of a backlog may well suffice to avoid difficulty (^{ii}b), while the simple choice "pay and go on pile A, or don't pay and go on pile B" can mitigate difficulty (^{i}c). But if backlogs become sizable or chronic, such a policy serves the general welfare poorly. The recent experience of the American Institute of Physics and the American Institute of Aeronautics and Astronautics has been favorable in that difficulty (^{ii}b) has been reduced without development of a large backlog.

Although the necessary input data are not at all accurately known, it is instructive to sketch an approximate estimate of the dollar value of the loss to society resulting from delays in

publication. Suppose the utility of a published paper at a time t after the work is completed varies as exp $(-t/t_0)$, where t_0, which is related to but not identical with the obsolescence half-life discussed above in Section IIIC.2, is typically rather more than five years. Then one might say that a month's delay in publication causes a loss of $(1 \text{ month}/t_0) < 1/60$ of the total value of the published paper. If we guess the latter to be, on the average, about 15 times the total cost of producing (and distributing) the published paper, the loss per month of delay comes to a little less than one fourth of this production cost. An average delay of a month for a sixth of the papers in a journal thus would cost society only four percent of the production cost of the journal; a delay of six months for all the papers, on the other hand, may cause a loss bigger than the entire production cost.

Suggestions for governmental policy. If publication is to be supported via use of grant or contract funds for page charges, we feel that such funds should continue to be available under the conditions stipulated in the Federal Council's 1961 statement[5], but that the scope of this policy should be extended to allow payments to nonprofit publishers under certain other conditions as well, that is, to allow these publishers more individual freedom in setting the policies of their journals. Specifically, page charges for publication of government-sponsored work in a nonprofit journal should be payable from grant or contract funds whenever the journal certifies its willingness to publish as promptly as possible, without payment of page charges, acceptable material from institutions to whom such payment would be a hardship, up to a specified reasonable limit. This limit might be set as a specified

fraction (e.g., one fourth to one third) of the pages of each volume, or it might be specified only by a requirement that the average difference in publication time lag between papers that pay page charges and those that do not should not exceed a certain limit (e.g., two months). In the latter case the monitoring might be carried out by designating an agency, such as the Office of Science Information Service of the National Science Foundation, to maintain a list of approved journals meeting the conditions outlined above. Nonprofit journals should be asked to submit to this agency annual cost and income statistics, and statistics on publication time lags, and the like. If the average difference in time lag between paying and nonpaying papers for any year became too high, the journal could be required to satisfy the agency that reasonable steps were being taken to correct the condition—for example, a raising of subscription price.

We add a further restriction that seems to be implied in the present policy[5], though not explicitly stipulated; this restriction seems administratively feasible if the recommendation of the preceding paragraph regarding financial reports to a monitoring agency is adopted. The page charge should not significantly exceed the prerun cost per page. We add this because higher page charges do not seem to be necessary at present and also because, if a uniform page charge is assessed on all with funds to pay, whether governmental or not, it would not be fair to ask industrial organizations and others without governmental support to subsidize the publications of those who do not pay. However, we see no reason, other than administrative cumbersomeness, that the government should not, if it so wished, pay page charges larger than

those assessed for nongovernment-supported work to effectively fund publication of work of the latter type done in universities and nonprofit institutions. Such oversized page charges would be one possible way of enabling each federal agency to support journals in proportion to their degree of involvement in the fields that this agency supports. However, as far as we are aware this step is not necessary at present.

Papers of foreign origin. Difficulty (iia) has slightly different implications for foreign papers as compared with domestic ones. While it can be argued that our government and the professional societies of our country have an obligation to support publication of all domestic research and development work, the responsibility of groups in one country to support the publications of another is questionable. A reasonable amount of cross-publication is extremely desirable to avoid insularity and achieve cross-fertilization, but too one-sided a subsidy by any country of the publication of work of another fully developed country is not healthy. It may occasionally, though hopefully only rarely, be necessary for journals using the "two pile" system to make it into a "three pile" system, by budgeting, separately, reasonable amounts for support of prerun costs of nonhonoring papers of domestic and foreign origin. Another conceivable possibility is that in some cases a system of international credits could be worked out for page charges.

Miscellaneous measures. In addition to the measure we have advocated as the most promising for optimizing the benefits of a page-charge system and minimizing undesirable side effects, there are

many further measures that have been or could be suggested; some of these have merit, others do not.

It is sometimes suggested that there should be a ceiling on the sizes of page charges payable from government funds. The object would be to cut down support of journals with grossly inefficient prerun operations and to reduce the temptation to charge more than prerun costs. We feel that these objections do not require such a measure. According to the data we have obtained (see, for example, Figure 35), serious prerun inefficiency is rare among the major page-charge journals; when it occurs, there will be pressures from authors and supporting societies to eliminate it. As for charging more than prerun costs, this can be eliminated by the monitoring scheme proposed above. Imposition of ceilings would have the disadvantage of discouraging innovations that might be socially valuable but that would increase prerun costs. Moreover, it would be hard to reconcile with the constraint of simplicity, since, to be fair, ceilings would have to vary with the type of material published. (See the discussion of prerun costs in Section IIIA.4.)

There are other measures, besides the two-track system, that journal publishers can take to improve the honoring of page charges or mitigate side effects. One that has been widely used is pricing reprints to authors of nonhonoring papers at a rate well above the differential cost of producing them. Authors apparently have been better able to find money for reprints, which they always want, than for page charges; when they really lack money, they can forego reprints without embarassment and the basic publication of their work is not

affected. This device, however, cannot be relied on in the present age of easy copying. Another measure, used, for example, by the American Mathematical Society, has been requesting research institutions to support the society through "institutional memberships," with sizable dues that are credited against page charges incurred by authors from the institution in question. Another proposal is that of waiving page charges only for authors who apply for and receive a "grant," and imposing a limit on the number of pages by any one author for which the society will provide a grant in any one year. Such a scheme can have some success if the authors from truly impecunious institutions are usually significantly less productive than those with better financing.

Thoughts for the future. We have suggested an agency such as the NSF Office of Science Information Service for the monitoring role because it would be inappropriate for government agencies to base their decisions on evaluation by a nongovernmental body. But we feel that a continuing analysis of journal economics by the NAS-NAE Joint Commission recommended in the SATCOM Report[2] can provide invaluable assistance to the federal monitoring agency.

The question of possible use of government funds to support prerun costs of journals of for-profit publishers is an interesting one. If a policy for such use could be developed that would give a reasonable assurance that the money so used would result in lowered subscription prices, hence in larger circulations, society would be significantly benefited. However, we have not been able to devise any policy that offers such an assurance. We feel that these private journals often fulfill a very useful role and that they would be even more useful

if they were cheaper. As we believe there is no danger of their being driven out of business by any of the forms of support for nonprofit journals we are considering, we feel content to let the present pattern of nonsupport for these journals continue for the immediate future. For the more distant future, it might be possible to make the payment of page charges to commercial journals from government funds conditional on some sort of renunciation of copyright. For example, if the concept of "user journals" described at the end of Section IIID.7 should be widely adopted by scientific and technical societies (or even commercial publishers), it might be possible to allow page-charge payments to those journals that agreed to supply their proofs for reproduction in any "user journal" (suitably defined) that desired them.

C. Suggestions for Societies and Other Publishers of Journals

1. Page Charges

In the following section, we present guidelines to assist nonprofit journals in deciding when to introduce page charges and at what level.

The three most important advantages of having page charges are that: They make the operation of a journal more stable with respect to fluctuations in input, in demand, and to some extent in costs (see Section IVA.5); they enable a journal to be marketed at a price not far above runoff cost, thereby making it available to a group of buyers who, though not the most important ones, can still benefit significantly from it (Sections IVA.1, IVB.1, and IVB.4); and they provide the publisher greater freedom to innovate and introduce new user-oriented services (see the AIP example in Section IIID.3). Against these one

must weigh the disadvantages: Other than extra administrative work, the latter include the possibility of driving some authors to other journals and the possible embarrassment of some institutions who must confess their inability to pay, or the possible delaying of some papers if a "two pile" system is used (see Section IVB.4). The embarrassment can be minimized by adoption of a "two pile" system, since the offer becomes "pay and receive a certain service or don't pay and receive a lesser service." If the publication schedule is sufficiently rapid so that even the second pile is likely to be published as soon as papers submitted to a competing non-page-charge journal, the motivation for flight of authors will be greatly reduced; it will be further reduced if government agencies supporting work submitted to the journal adopt the recommendations of this Report regarding nondiversion of money budgeted for publication.

These considerations suggest the following guidelines: Page charges are not worthwhile for a journal that feels its economic position to be very stable and that can be sold, without page charges, at a price low enough to make the triangular area of CEF in Figure 31(b) no more than about five percent or so of the production cost. (This last condition amounts to saying that the buyers priced out of the market suffer a loss through not having the journal that is negligible on the scale of the operation being considered.) All journals should adopt page charges whenever either of the conditions just stated are not met provided that: (a) most of the work submitted has government support or support from industries that accept a responsibility for communication of information; and (b) the supporting agencies have adopted policies

similar to those recommended in this Report regarding nondiversion of money budgeted for publication and the use of such money for page charges in journals with a "two pile" system. When one, or both, of these premises is not met, a careful weighing of pros and cons is necessary. Due account should be taken of the possibility of improving economic stability through marketing at a per-volume rate (see Section IVA.5 above).

When page charges are introduced, their magnitude should be set with several considerations in mind. If the contributors to a journal are not used to page charges, they will need to be educated to understand them, and they must find room for them in their budgets. These adaptations will be easiest if the page charges are not too abruptly increased to a large value. While stability is optimized when the page charges fully cover the prerun costs (see Subsection A.5), it may be politically unwise, or even contrary to policies of funding agencies (see recommendations in the main Report), for them to exceed the prerun costs of that part of the material for which they are honored. If a journal has appreciable sources of income other than page charges and subscriptions, it must consider to what extent these can be used to reduce the area of the triangle in Figure 32; when this area becomes negligibly small, further lowering of price through increased page charges is of benefit, if at all, only by virtue of its effect on stability and freedom to innovate.

2. Concern for Users

We have pointed out in Section IVA.1 that the social value of scientific and technical journals is typically an order of magnitude

larger than their total production cost and in Section IIIC.1 that the value of the time invested by readers in using them is also many times the production cost. It follows that any modifications of content, format, promptness, or accessibility that will significantly help the bulk of the users of a journal will be well worth a sizable increase in production cost from the standpoint of society. In the way of specific suggestions, we shall offer here only a few scattered thoughts. More important is the general exhortation that scientific and technical societies should do much more serious research than most of them have yet done on the ways in which their members use journals and on the utility of possible modifications in the journals these societies publish.

The rationale for several suggestions to improve the utility of journals has been discussed in previous parts of this Appendix, and such suggestions need only be briefly mentioned here. The possibility of selective dissemination of individual articles to individual users (Section IIID.7) should always be kept in mind, and when and if it appears economically feasible in any field it should be attempted. The less individual "user journals"[72] described at the end of Section IIID.7 should be studied similarly. The possible need for subdivision of overly bulky journals should always be borne in mind[13]; we have commented in Section IVA.4 on the utility of subdivision in forestalling the birth of undesirable journals. Finally, recalling the wide dispersion in editorial time invested by different journals, as shown in Figure 10 of Section IIIA.4, we urge societies and other publishers of journals to give much more attention than they have previously to the possibility of improving the utility of their journals through more meticulous

editing and through programs for education of authors. Some suggestions by Michaelson[73] on the plan and format of articles and abstracts provide an example of the types of changes that could be instituted; see also the discussion of pros and cons by Kuney[36].

One often hears the proposal, usually made in the interest of economizing on production costs, that research articles should not be published in full, as now, but that the widely circulated journals should publish only a condensed version of each article and that the full version should be stored in a central repository, available on demand to any interested party. It can be convincingly argued, however, that the material stored in the repository would be much less used than if it were available in journals and that the loss in its value to its potential users would be much larger than the saving in publication costs. The first step in the argument—the statement that material in a depository is much less used than that available on library shelves—is attested by the experience of almost anyone who has done intensive research and is further supported by the studies [57,58] we have cited in Section IIIC.2 regarding the correlation of utilization with accessibility of different types of information channels. A major reason for this is the delay that necessarily (at least in the present state of information-transfer technology) accompanies getting something from a repository. Often one consults several papers, including their details, sequentially in pursuing a train of thought. If the train of thought has to be interrupted at some point and resumed at a later date, a tremendous loss in efficiency results. While it can be argued that those to whom the information in a paper is most valuable will indeed make the effort to

obtain it from the repository, even these people will suffer a significant loss in efficiency from the enforced waiting period. When this fact is combined with the fact that the total readership of any paper will be greatly reduced, it becomes obvious that the loss in value received from the research papers in the repository will be a significant fraction of the value now received from them and, according to our estimates of this latter value, well in excess of the cost of publication.

These arguments against the repository idea for research papers in general do not apply with the same force to unusually bulky or unusually specialized material; indeed, such material is even now not usually published in full. Fortunately, however, there is an intermediate way of making such material available that provides rapid access with low cost. This is the device of putting it on microfiche cards, prepared from author-supplied copy and distributed with issues of a journal (see Section IIID.2).

3. Composition and Format

We have indicated in several places that typewriter composition and photo-offset printing offer advantages in economy and speed over traditional type composition and letterpress printing (see Sections IIIA.4, IIID.1, and IIID.5). Although some readers have a subjective feeling that the typewriter characters and unjustified margins are "less nice," studies of reading speed and comprehension do not seem to have revealed any perceptible inferiority[74]; moreover, the experience of letter journals, which nearly always use typewriter composition, and of the few regular journals that use it, has been favorable. We recommend wider adoption

of typewriter composition. Other technologies of composition, for example, computer-controlled photocomposition, may offer similar or greater advantages in the future[36].

A tremendous saving in composition costs, of course, could be achieved by photo-offset printing of copy as originally supplied by authors. While the purely esthetic shortcomings of the nonuniform appearance of the resultant product might not imply less efficient reading, there might well be a loss of efficiency from such factors as page size, limited typographic range, and, above all, nonuniform conventions for bibliographic citations, format of equations, and the like. Journals probably should not adopt such a system without careful tests of reader efficiency.

As a final comment we might point out the desirability of research on the correlation of efficiency of reading with size of page for highly technical (especially for mathematical) material. Although research on legibility is a well-established field, as evidenced by the recent formation of an international committee in the field[75], size of page has often been treated as of minor importance[62]. In this respect, technical or mathematical material may be different from nontechnical prose in that the reader frequently needs to refer to another page for a figure, a table, an equation, or a definition. If it should turn out that large pages save a significant amount of the reader's time or improve comprehension, journal publishers should be guided accordingly. The considerations of portability, convenience for reading in armchairs, and the like that often limit page sizes in other books and magazines are less important for most scientific and technical journals, which are

usually read at a desk or table. Excessive size, of course, would be inconvenient for library shelving.

4. Miscellaneous Suggestions

We have noted in Section IIIA.4 that the publisher of a large journal with frequent issues, or of a number of different journals, can save on copy-editing and similar costs by having a more even work load than the small publisher. (The latter is often tempted to maintain a uniform work load by building up a backlog of unpublished papers, a practice which has undesirable consequences.) A similar gain in efficiency may occur in subscription handling. The larger publisher can also negotiate more effectively with printers, compositors, and advertisers. Hence we suggest that <u>when feasible, small societies in related fields should federate into larger units for their publishing activities</u>.

Scientific and technical societies that contract with commercial publishers to publish their journals, or that give some sort of society sponsorship to commercial journals, should seek terms of agreement that will <u>ensure as large a useful circulation as possible</u>. Besides the common reduced rate for society members, it might be helpful to have limitations on price per kiloword to libraries, and perhaps reduced rates for multiple institutional subscriptions.

We have mentioned in Sections IVA.4 and IVA.5 that the economic stability of a journal is helped by its being marketed at an announced price per volume of a given size, rather than at an announced price per year; <u>we recommend per-volume pricing to all journals that feel threatened by bulk fluctuations</u>. The alternative of building up large backlogs of papers awaiting publication can easily mean a larger loss to society

than the total production cost of the journal, as the sample calculation in Section IVB.4 shows.

It appears to us, and to others[76], that some journals have unreasonably large over-runs for back-number stocks. Publishers should avoid being guided by habit in such matters and should periodically modify their practices in the light of reasonable estimates of the future demand for hard copy as opposed to microform.

Finally, it should be obvious from all portions of this Appendix that publishers of journals should keep their books in such way that the various prerun, runoff, and "optional" items in costs (see Figure 8) are separately identified.

ATTACHMENT A: ORGANIZATIONS AND INDIVIDUALS THAT HAVE CONTRIBUTED INFORMATION USED IN THIS STUDY

In response to our letters of inquiry, described in Attachment B, data on costs, circulation, and the like for selected journals were kindly supplied to us by the societies listed below. In many cases the members of the publication staffs subsequently were extremely helpful in supplying additional information and suggestions:

American Chemical Society (D.W. Gushee, R.L. Kenyon)

American College of Physicians (F.C. Dauterich, Jr.)

American Geophysical Union (A.F. Spilhaus, Jr.)

American Institute of Aeronautics and Astronautics (R.F. Bryans)

American Institute of Physics (G.F. Gilbert, H.W. Koch, A.W.K. Metzner, W. Waterfall, H.C. Wolfe)

American Mathematical Society (G.L. Walker)

American Physical Society (J.A. Burton, S.A. Goudsmit)

American Physiological Society (S.F. Leslie)

American Psychological Association (H. Orr, H.W. Seal)

American Society of Biological Chemists (R.A. Harte)

Institute of Electrical and Electronics Engineers (W.R. Crone, E.K. Gannett)

Mineralogical Society of America (A. Van Valkenburg)

Mycological Society of America (J.G. Sutton)

Society for Industrial and Applied Mathematics (I.E. Block, J.C. Stuliglowa, R.K. Windsor)

In addition, many other people have supplied valuable isolated items of information. These include editors of journals and officials of commercial publishing organizations (E.V. Cohen, G.J. Dienes, W.C. Dunlap, B.C. Frazer, E.J. Huibregtse, A.R. Liss, C.S. Mill, P.M. Morse, F.F. Rilke, G.E. Schindler, Jr.), library scientists (D.T. Ho, R.A. Kennedy, J.K. Lucker, R.O. Stanton), and others (H.W. Etzel, W.R. Gruner, S. Keenan).

ATTACHMENT B: JOURNAL POPULATION AND SAMPLING PROCEDURE

We interpreted our directive to study primary journals as meaning that we should focus attention on those journals that carry the brunt of the responsibility for the initial communication of new knowledge in science and technology to workers on the intellectual frontiers. We also interpreted our assignment as directed mainly at journals published in the United States, but including some concern for journals published abroad insofar as these are possible alternative media for the publication of work done in the United States.

While it has been estimated[25,26] that even nearly a decade ago there were over 6000 scientific and technical periodicals published in the United States, it is clear that the population of interest for our study must be much smaller than this. Many of the journals contain only reworkings of existing knowledge or secondhand accounts of recent discoveries oriented toward some particular readership not working on the frontiers of knowledge. Many that do contain first publications of new findings are journals with only a local readership and do not provide wide dissemination. But these criteria of "primariness" and "publicness" are both extremely fuzzy. It may help to give some examples of journals that are clearly "primary" and/or "public," of journals that are clearly not the one or the other, and of journals that are on the borderline:

Clearly primary and public:

Annals of Internal Medicine

Duke Mathematical Journal

IBM Journal of Research and Development

Mycologia

Semiprimary, but clearly public:

American Journal of Physics

Bulletin of the American Physical Society

Heating, Piping, and Air-conditioning

Journal of the American Medical Association

Physiological Reviews

Clearly not primary, but clearly public:

American Scientist

Bell Laboratories Record

Physics Today

Product Engineering

Today's Health

Clearly primary, not widely circulated, though not intended to be purely regional in appeal:

Bulletin of the New Jersey Academy of Sciences

Mercian Geologist

Very local circulation (probably usually not primary):

Bulletin of the Geological Survey of Alabama

Journal of the San Antonio District Dental Society

Minnemath Center Reports

New Jersey Bell

The population that is of interest for a study like the present one, or that of Reference 7, includes the first category of journals, and some of the second and fourth, the fuzziness of the boundaries of this population being measured by the sizes of the second and fourth categories. A random glance at the Union List of Serials suffices to

establish that the vast majority of scientific and technical journals fall in the last three of the categories displayed above. One can use various approaches to get rough estimates of the fraction of journals in various fields that would be of interest for our study. For example, one can estimate the percentage of journals in some broad field that are primary and widely used by counting the number of primary journals in this field in a library that is considered fully adequate by a large and active research group in this field. Comparing this number with estimates[25,26] (corrected for growth between 1962 and 1968) of the total number of journals in the field then gives a percentage, which can then be applied to other fields judged similar to the first one. In the pure-science fields one can, alternatively, compare the list of journals covered in some broad field in Reference 7 with the number in the good library just mentioned, and so arrive at a figure for the fractional coverage of the list in Reference 7.

Both these approaches are too crude to justify giving details of the calculations here; they yield a figure of approximately 300-400 widely used U.S. primary journals in 1968 in what Gottschalk and Desmond[24] call the "natural and physical sciences." In this area the boundary between primary and nonprimary journals is reasonably sharp. In technology, medicine, and agriculture this boundary is much less sharp. By the methods described, one can estimate a number of widely used U.S. primary journals in engineering and technology that is rather larger than the number just quoted for science but probably no more than about twice as large; the choice of a particular number is very much a matter of taste. In medicine and agriculture we have less data to go on: In

each of these areas the total number of U.S. journals is considerably larger than in pure science but considerably smaller than in technology[26]; the ratio of widely used primary journals to the total in the area is probably intermediate between the ratio for science and for technology. A plausible guess would assign comparable numbers of widely used U.S. primary journals to each of these two areas, with the total for the two a little less than the total for technology.

Though all of the areas mentioned should have been of some concern for this study, our samples, like that of Reference 7, were concentrated much more strongly in science than in technology, were even sketchier in medicine, and did not extend at all into agriculture. In science, Sample (1), as described at the start of Section III, contained about 85 or 90 U.S. journals in physics, chemistry, and mathematics (probably a fairly complete coverage), 40 to 45 in biological and behavioral sciences (meager coverage), and about a dozen in other fields of science (very meager). It contained 56 foreign journals in physics, chemistry, and mathematics, a sizable sample but only a fraction of the total available; in the other science fields only a few foreign journals were sampled. In engineering, Sample (1) contained over 40 U.S. journals in electrical and communication engineering (again probably a fairly complete coverage) and a little over 30 in other engineering fields (meager coverage). Again only a few foreign journals were sampled.

The size and coverage of our Sample (2) are fairly well described by the paragraph on it at the start of Section III and the list of societies in Attachment A. Most of the societies queried publish

many more journals than those for which we requested data; to avoid making excessive demands we tried to select a few journals of each society that would be representative of the entire range of their journals, for example, some with a basic science emphasis and some with an applied emphasis. However, some societies volunteered at least partial information on all of their journals.

Sample (3) overlapped Sample (1) in that 1968 data on circulations, page-charge honoring, and the like often were obtained from miscellaneous sources (e.g., the CBE Survey[15], References 16 and 18, and other private communications) for journals already included in Sample (1). In addition, however, these sources supplied a valuable supplement to Samples (1) and (2) in fields such as biology where the coverage of these samples was incomplete: There were 42 journals in Sample (3) not included in Samples (1) or (2); most of these were biological.

The letters that were sent to the societies listed in Attachment A (and to a few other societies and nonprofit publishers who were unable to respond) contained a request worded as follows:

"With these remarks as background, let me describe the information we would like to get from you, if you have it readily available, on the journal or journals mentioned at the bottom of page 1, or, if it proves more convenient for you, on other journals similar to each of these:

1. Bulk of material published in each journal (e.g., number of research pages and words per page), how this bulk has changed over the last decade or so, and how it is expected to behave in the immediate

future. Points at which any journal has been subdivided should of course be noted.

2. Subscription prices and number of subscribers in each class ("member" or "individual" versus "full-rate" or "institutional"); how these figures have changed over the last decade or so, including especially the effect of subscription-rate changes on circulation. The distribution of the subscriptions between domestic and foreign would also be of interest. If a journal has been subdivided, the average of the number of subscribers to the different sections is the figure of most interest, but it would also be interesting to know the effect of the subdivision on the number of different individuals or institutions subscribing to any section, as well as on the average circulation.

3. Page charges. If page charges are assessed against authors' institutions, when were these first introduced, and how have they changed since? What percentage of papers have been honoring the page charge, and has this percentage shown any marked change recently? Is payment obligatory, and if not, do honoring and nonhonoring papers receive any different treatment, or are they likely to in the foreseeable future? How are the nonhonoring papers distributed between domestic and foreign institutions?

4. Costs. With a reasonable apportionment of overhead expenses and value of any office space and the like that may be donated by another organization, what were, for each journal in 1968, the prerun (editing and refereeing, copy editing, composition, proofreading, preparation of illustrations, indexing, etc.) and runoff (paper, printing, binding,

mailing, subscription maintenance, etc.) costs? (These can be stated either as total dollars, or as dollars per research page per subscriber, respectively, as the information necessary for interconversion is contained in (1) and (2) above.) Some indication of the rate at which these costs are changing would also be helpful. If a journal includes advertising or other nonresearch material, the costs and/or income of this should be split off and stated separately. Costs of reprint preparation should also be separated, and the amount of runoff cost attributable to the accumulation of a stock of back numbers should be indicated.

5. Income. Besides subscription and page-charge income, already covered in items (2) and (3), what other income did each journal receive (e.g., sales of reprints and back numbers, subsidy from society funds, advertising income)? Has this changed markedly in recent years?

6. Reprography. Can you attribute any changes in the demand for your journals to the recent rapid expansion of reprographic services? What do you anticipate for the future?

7. Miscellaneous. Have you ever been troubled with backlogs due to economic factors? Have you had scheduling troubles with compositors or printers? What is the current range of intervals from receipt of a paper until its appearance in print? Have you recently made, or do you plan to make soon, any major changes in the technology of composition or printing? Last, but by no means least, are there any further worries or concerns that you would like us to give attention to?"

ATTACHMENT C: MATHEMATICAL STUDIES OF MODELS

1. Condition for Economic Viability of a Journal

Let the number of subscribers n at price p be approximated by an exponential function:

$$n(p) = n_0 e^{-\alpha p}. \tag{C1}$$

The break-even price p_b is that for which the explicit cost terms in Equation (2) equal subscription income pn(p):

$$p_b n(p_b) = s + rn(p_b), \tag{C2}$$

where s is the prerun cost and r the runoff cost per subscriber. The maximum-profit point comes at the price p_{opt} for which the derivatives of the right and left of (C2) with respect to p are equal, that is, where the two curves in Figure 32 are parallel. As the cost curve in Figure 32 is raised or the income curve lowered, there will come a time when the two curves meet only in a point of tangency, that is, $p_b = p_{opt}$, and if the curves are shifted beyond this there will be no intersection, that is, (C2) will have no real root. We wish to compute the relation between s, r, α, and n_0 when this occurs.

The equation for p_{opt}, obtained by differentiating (C2) and noting that $n^1(p) = -\alpha n(p)$, is

$$1 - \alpha p_{opt} = -\alpha r \tag{C3}$$

With $p_b = p_{opt}$, (C2) gives with (C1) the critical condition for viability:

$$n_0 = \alpha s e^{1+\alpha r} \tag{C4}$$

or

$$n_{crit} = n_0 e^{-\alpha p_{opt}} = \alpha s. \tag{C5}$$

A value $n_{crit} = 1000$ would thus be consistent with the typical prerun cost s = 50 dollars/kiloword if α is about 0.2 (cents/kiloword)$^{-1}$, as stated in Section IIIA.2.

2. Effects of Assuming Different Elasticity of Circulation with Respect to Price for Individual and Institutional Subscribers

Suppose we replace the simple assumption (C1) by one that distinguishes individual from institutional subscribers. A simple model that does this is

$$n(p) = n_{0m} e^{-\alpha_m p} + n_{0e} \ell^{-\alpha_\ell p}, \tag{C6}$$

where we use the subscripts m (member) for individuals and ℓ (library) for institutions. We can let p be always the institutional price, even if individuals are charged a lower price, since the price ratio can be accomodated by changing α_m. We expect α_m to be several times α_ℓ. The price p_{opt} of maximum profit, given in general by

$$n(p_{opt}) + (p_{opt} - r)n'(p_{opt}) = 0, \tag{C7}$$

is given for this model by

$$n_{0m} e^{-\alpha_m p_{opt}} \left[1 - \alpha_m (p_{opt} - r)\right] + n_{0e} \ell^{-\alpha_\ell p_{opt}} \left[1 - \alpha_\ell (p_{opt} - r)\right] = 0. \tag{C8}$$

Let $p_{\frac{1}{2}}$ be the price at which $n(p_{\frac{1}{2}})$ is half n(0). For the one-exponent model (C1) we have

$$p_{\frac{1}{2}} = 0.693/\alpha, \tag{C9}$$

$$p_{opt} = r + \alpha^{-1} = r + 1.44 p_{\frac{1}{2}}. \tag{C10}$$

If $n_{0m} = 2n_{0\ell}$, and $\alpha_m = 3\alpha_\ell$, for example, (C6) and (C8) give

$$p_{\frac{1}{2}} = 0.32/\alpha_\ell \tag{C11}$$

and if r = 0,

$$p_{opt} = 0.56/\alpha_\ell = 1.76\ p_{\frac{1}{2}}, \tag{C12}$$

that is, a modest increase of $p_{opt}/p_{\frac{1}{2}}$ above the value given by (C10). In the reasoning of Section IIIA.2 based on prices of commercial journals, this increase could well be of the same order as the amount by which these journals set their price below the maximum-profit point.

3. Circulation at Maximum Profit

Let us now suppose nothing more than that the curve of n(p) against p is monotonic and concave upward, as in the example of Figure 31. The maximum-profit condition is

$$n(p_{opt}) = -(p_{opt}-r)n'(p_{opt}). \tag{C13}$$

We have

$$n(r) = n(p_{opt}) - \int_r^{p_{opt}} n'(p)dp > n(p_{opt}) - \int_r^{p_{opt}} n'(p_{opt})\ dp \tag{C14}$$

$$= 2n(p_{opt}).$$

Thus, as stated in the text of Section IVA.1, under the concavity assumption the circulation of a journal marketed at maximum profit is always less than half what it would be if the journal were marketed at runoff cost.

4. Costs, to U.S. Institutions, of Different Publication Patterns

To analyze the economics of the flight to foreign journals, described in Section IVA.4, consider the research published in some particular field by N institutions in the United States active in this field. Let some part of this research, say K kilowords of it annually, be subject to publication either in domestic page-charge journals or in foreign commercial journals, according to the direction of some policy decision. Let the page charge of the domestic journals be C per kiloword, and let the institutional price be p_d for these journals, p_f for the foreign ones. Then to publish their work and purchase it back in the journals, for their libraries, these institutions must pay annual amounts

domestic publication: $KC + NKp_d$

foreign publication: NKp_f

The difference of these is

$$K\left[C + N(p_d - p_f)\right], \tag{C15}$$

and can be of either sign. For example, if C = 44 dollars and p_d = 0.6 cents, per kiloword, as for the Journal of Organic Chemistry, while p_f = 4.8 cents/kiloword, as for Tetrahedron, (C15) becomes negative (i.e., publication abroad more expensive) whenever N > 1050 institutions.

NOTES

1. Discussions of these problems have often occurred in unpublished presentations, though some have been published. As examples, we cite:

   Gushee, D. Problems of the Primary Journal. Presentation to the American Chemical Society Division of Chemical Literature, 157th Annual Meeting of the American Chemical Society, Minneapolis, Minnesota, April 1969.

   Lee, M.O. Problems of Financial Management of Scientific Journals, Science, 119, 530-532 (1954).

   Pasternack, S. Is Journal Publication Obsolescent? Physics Today, 19, 38-43 (1966).

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   See also References 3, 4, 12, and 13.

2. National Academy of Sciences-National Academy of Engineering Committee on Scientific and Technical Communication. Scientific and Technical Communication. A Pressing National Problem and Recommendations for its Solution. Washington, D.C.: National Academy of Sciences (1969).

3. Samples of criticisms of the page-charge system are:

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   Letters by J.S. Levinger, J. Schaefer, P.D. Hambourger, S.A. Goudsmit and G.L. Trigg, K.E. Collins, and L. Wolfenstein in Physics Today, 22, 11-17 (1969).

In addition, there has been much correspondence about this topic and numerous committee discussions of it; we would like to acknowledge especially a number of the arguments stimulated by R.K. Wakerling of the Technical Information Division, Lawrence Radiation Laboratory, University of California.

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